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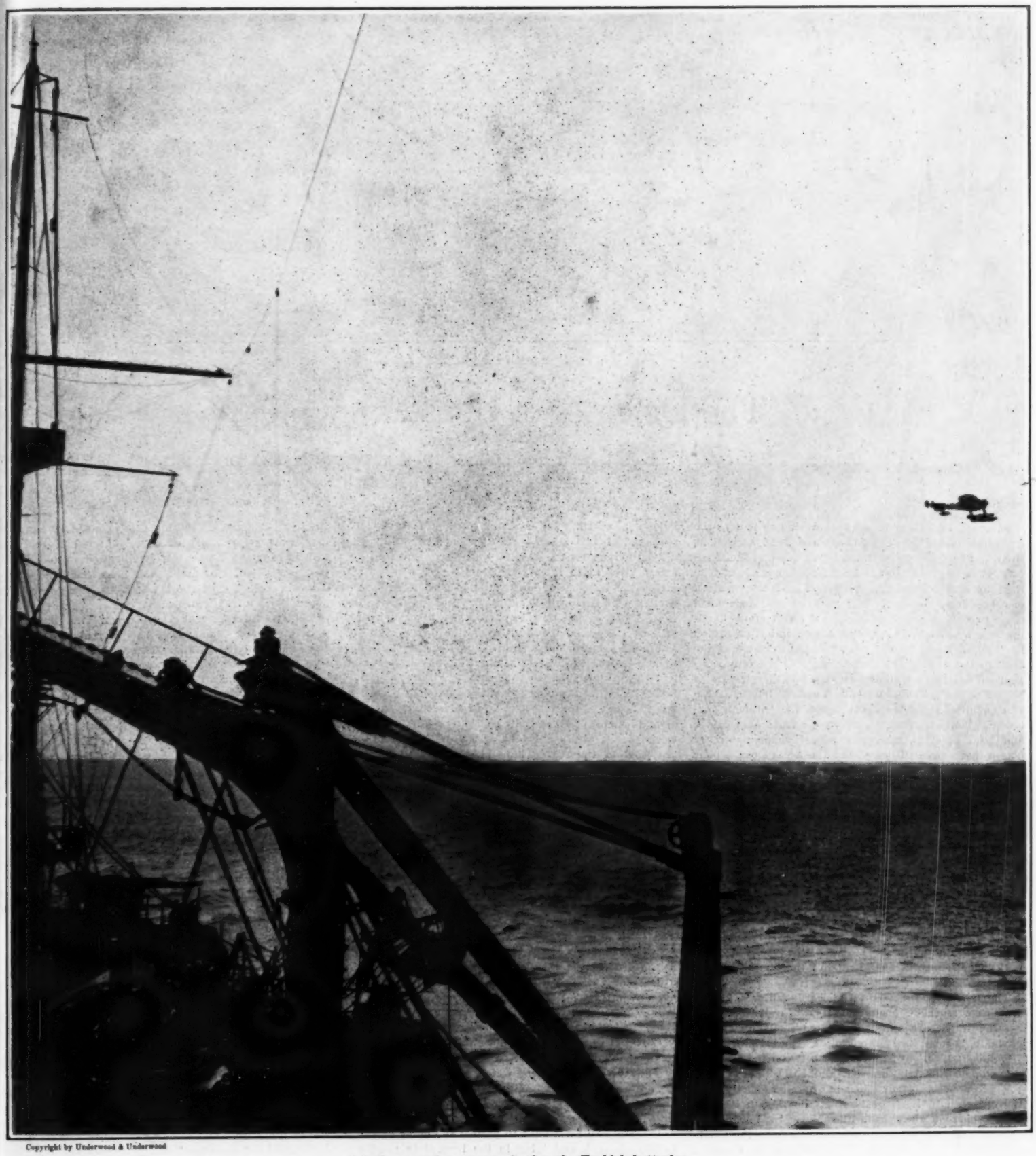

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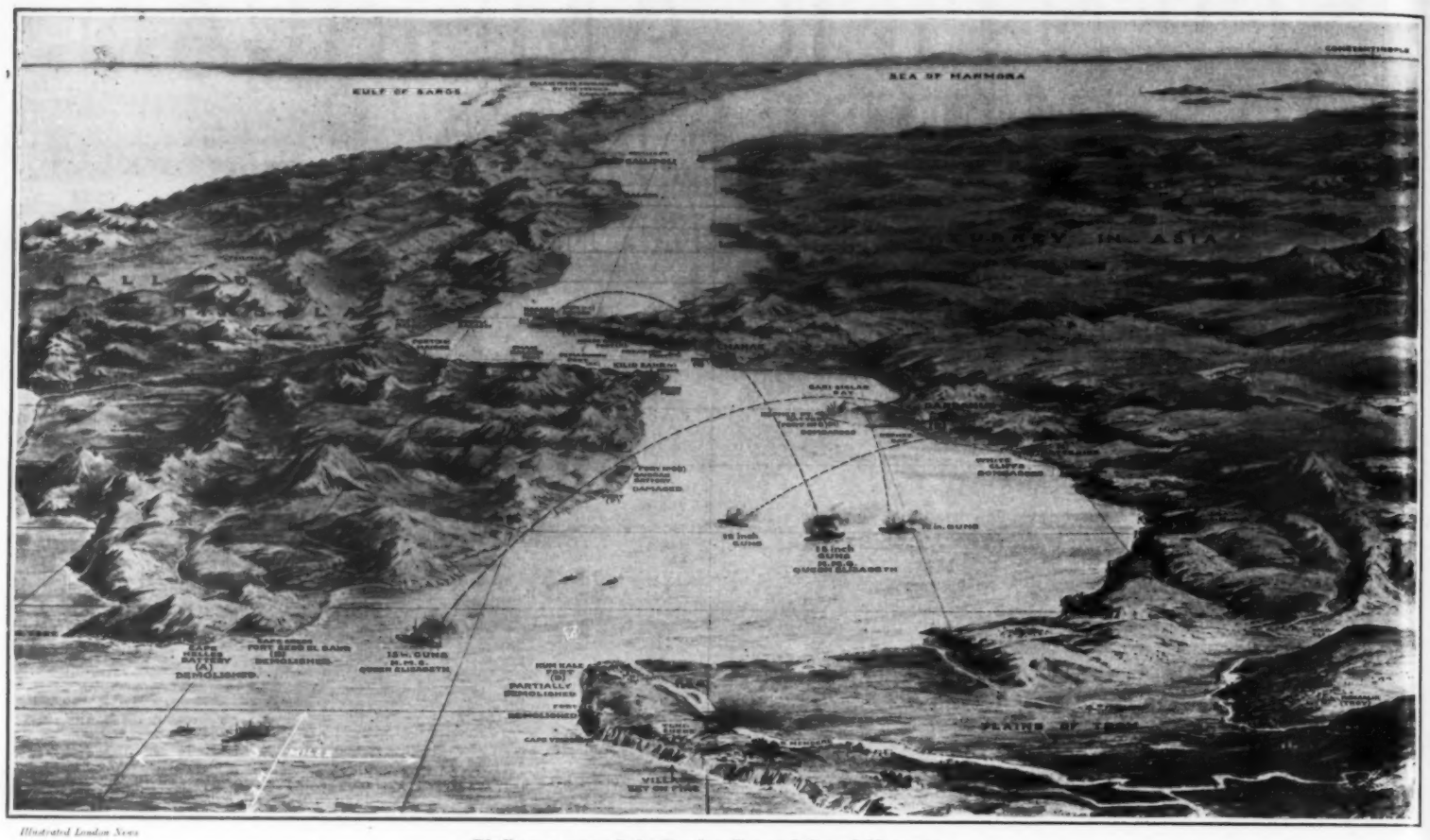
A hydro-aeroplane reconnoitering the Turkish batteries.

THE CAMPAIGN OF THE ALLIES ON THE DARDANELLES.—[See page 2.]



Illustrated London News

Bird's eye map of the Dardanelles and Sea of Marmora.

The Defenses of Constantinople*

Ample Preparations That Have Been Made by Turkey to Resist Invasion

By H. Charles Woods

For centuries, Constantinople, covering as it does the great land route between Europe and Asia, as well as the water highway between the Black Sea and the Mediterranean, has been the object of many aspirations. The reigning monarch in this wonderful and cosmopolitan city has from the earliest times been able to control these two great thoroughfares, as a result of the fortifications constructed to protect his capital from attack by sea and land. In the past, too, the defenses of the Dardanelles and of the Bosphorus have not only safeguarded the position of the capital, but they have also protected the Sea of Marmora. Thus, as long as these two channels remained impregnable, the Ottoman government could not only bring troops from Asia Minor and land them at Constantinople, Rodosto, or other places in European Turkey, but the Sultan could pour his armies into Asia Minor, thence to send them by railway to an area from which they have now endeavored to make raids across the Egyptian frontier. In a word, for the last few decades the strength of the defenses of Constantinople has been one of the most material factors in the whole Near Eastern question—a factor which may well have been considerably modified, if not completely obliterated before the appearance of these lines in print.

The modern defenses of Constantinople are divided into three main groups:

(1) The forts on the Dardanelles.
(2) The Bosphorus forts.
(3) The Land Defenses, including the Chatalja Lines.

THE DARDANELLES.

The northeastern end of the Dardanelles is distant from Constantinople about 130 miles. The length of the Straits, which are winding and extremely difficult to navigate, is some thirty-three miles. The breadth varies from about 1,300 yards, measured between the towns of Chanak, on the Asiatic coast, and Kilid Bahr, on the European shore, to four miles or five miles shortly after the entrance to the Straits from the Ægean Sea. A strong current runs from the Marmora toward the Mediterranean. When the wind blows from the northeast, that is, more or less straight down the Channel, the difficulties of navigation and the speed of the current are considerably increased.

The Dardanelles are bounded on the northwest by the Peninsula of Gallipoli, and on the southeast by the mainland of Asia Minor. The Peninsula of Gallipoli is a long, narrow tongue of land, some thirty-five miles in length. Its width is only three miles, when measured across the Isthmus of Bulair, lying as it does to the northeast of the town of Gallipoli. More to the southwest it widens out, only to narrow again to a breadth of about four miles in the rear of the town of Maidos. The northwestern and western shores of the peninsula are washed by the waters of the Gulf of Saros and of the Ægean Sea.

The coast rises in many places precipitously from the water's edge. Nearly the whole of the country in rear of Maidos and of Kilid Bahr consists of hills which, in many places, attain a height of 600 or 700 feet above the level of the sea. These hills are intersected by small, rocky valleys, with steep, almost precipitous, sides. Much of this country is covered with scrubby bushes about two feet high, but the area immediately to the west and southwest of Kilid Bahr is prettily wooded, the trees extending almost to the sea shore. Unless the Turks and the Germans have recently improved them, the roads along and across the peninsula are bad, for in the past communication has usually been maintained by sea.

The most important town on the peninsula is Gallipoli, at the northeastern entrance to the Dardanelles. The town is essentially Turkish, and was the first to fall into the hands of the Osmanlis, soon after Sulieman Pasha crossed the Dardanelles and planted the standard of the Crescent in Europe in the year 1356. The only other places of any importance are Maidos and Kilid Bahr, lying much lower down the peninsula, the latter-named village being situated at the narrowest part of the Channel. Both these towns would be practically unknown and neglected were it not for the strategic value of the country which surrounds them.

The modern defenses of the Dardanelles, situated on the Peninsula of Gallipoli, may practically be divided into four groups:

(1) The two forts built to protect the outer entrance to the Channel, and lying in the immediate neighborhood of Cape Helles and Seddul Bahr. While we now know officially that these forts (lettered officially A and B) were armed with fairly big guns, their importance and power of resistance have always been considered as insignificant as compared with those constructed to guard the Narrows. In this first group, too, I would include two forts, or batteries (lettered F and I), which are situated, respectively, about seven and a half miles and about nine and a half miles from the southwestern extremity of the Dardanelles. They are both placed close to the water's edge.

(2) The forts in rear of and near Kilid Bahr, and therefore on, or immediately below or above, the narrowest part of the Straits. These forts (lettered from J to T, and which include another designated C C) constitute by far the strongest portion of the defenses of the Straits. Here the shore literally bristles with redoubts—eleven in number—some being hidden among the trees which cover the hills, while others are dotted about right down to the water's edge. Yildiz, or Tekeh Fort (lettered P), which has always been considered as one of the most important of these forts, lies at the extreme outer end of the group, and a little to the southwest of Kilid Bahr. It owes its strength to its height above the water, to its field of fire, and to the consequent difficulty of damaging it from the sea.

(3) The forts built to the north and northeast of Maidos—forts which, therefore, lie within or above the narrowest part of the Channel. These defenses, of which there are four (lettered D D, E E, and two not yet designated), are built upon the summits of the various hills which border this part of the Straits. They are so constructed as to be able to fire across the Channel toward Nagara Point, up the Dardanelles in the direction of Gallipoli, and down the Straits toward Chanak.

(4) The Bulair Lines. These defenses run across the Isthmus of Bulair, and thus defend the Peninsula of Gallipoli from an attack by a force advancing from the land side. They consist of three or four redoubts, connected by trenches constructed to cover the only road running into the Peninsula from the remainder of European Turkey. The importance of these lines has now been considerably diminished.

There is a great contrast between the two shores of the Dardanelles. The Asiatic coast is for the most part lower, and the appearance of the country is greener and more fertile than that of the Peninsula of Gallipoli. Communication by land is also bad, but a passable road connects Lapsaki (just opposite Gallipoli) with Chanak, and thence runs on down the coast toward the entrance of the Straits. The only center of any importance is

* From an article in the *Fortnightly Review*.

Chanak or Dardanelles, situated opposite Kilid Bahr.

Partly owing to their positions, situated for the most part more or less upon the level of the sea, the defenses of the Asiatic coast are, from a natural point of view, decidedly less strong than are those built upon the European side. These Asiatic forts may also be conveniently divided into three main or principal groups:

(1) The two forts built to protect the outer entrance of the Channel, which lie in the more or less immediate vicinity of Kum Kale. In this outer group, too, I would also include the batteries located near White Cliffs (lettered G), Dardanus Fort (lettered E), and the redoubt situated on Kephez Point (lettered H)

(2) The forts at and near the town of Chanak, and therefore on or near the narrowest part of the Channel. One of these, Hamidieh I. Tabia (lettered U), is located rather under a mile to the south of the town, another, Hamidieh III. Tabia (lettered V) lies at Chanak, and two more (lettered respectively W and X) are located above, but within a distance of about one mile from the Narrows themselves.

(3) The forts built on or in the neighborhood of Nagara Point, and therefore at a distance of about three and a half miles above the Narrows. These forts (lettered respectively Y, Z, and A A) occupy a very strong position, owing to the way in which this Cape and also Cape Abydos run out into the Channel, thus giving two of them good fields of fire in more than one direction.

The official news, informing us that ships, provided with long-ranged guns, have attacked the forts situated on both sides of the Narrows, by means of indirect fire, is far more important than it seemed to appear at first sight. In the past it has often been said that to shell the forts in this manner would probably only be a waste of ammunition, and that it might well be a danger were this method adopted at the same time that ships were endeavoring to force their way up the Channel. The success, now achieved, proves the first of these contentions to have been unjustified. Again, the danger to ships in the Channel, due to the fact that many of the forts to be shelled on the Narrows are situated absolutely on or just above the water's edge, has so far been obviated by using this indirect fire, not at the same time that, but as a preparatory measure before, the Allied Fleet endeavored to steam up between the towns of Kilid Bahr and Chanak.

The task of a fleet attempting to force a passage of the Dardanelles might also be greatly furthered were a force landed on the northwestern coast of the Peninsula of Gallipoli, where in places the shore is low and sandy. Some years ago, I believe in 1905 or 1906, the Turks, in order to endeavor to guard against a surprise of this nature, built a small look-out station on Gaba Tepe—a little promontory situated on the western shore of the Peninsula of Gallipoli, and lying at a distance of about seven miles to the northwest of Kilid Bahr. This look-out station, destroyed by the fire of an Allied cruiser on March 4th, was located in the immediate vicinity of the best landing places. Such a disembarkation would naturally be a matter of very considerable difficulty, for it would probably be strongly opposed by a force located in the hills, a force which would be in an extremely strong position unless that position could be rendered untenable by fire directed from the battleships lying in the Ægean.

An army once gaining possession of the hills which lie in rear of Maidos and of Kilid Bahr would be able to cut off the water supply of many of the European forts—a supply obtained through pipes from the hills in rear. Moreover, as most of the forts are open at the back, and as few, if any, of their guns can be fired otherwise than toward the Straits, such a force would, too, be able greatly to affect the accuracy of the aim, if not actually to silence the fire of the great Dardanelles guns which defend the all-important area of the Channel which has now grown to be known as the Narrows.

In addition to the fact that an army once occupying the hills in rear of Kilid Bahr would be able to threaten not only the European forts, but likewise those constructed on the Asiatic shores, it would also be possible for a force, landed on the Ægean coast of Asia Minor, to advance toward the Dardanelles. But to menace the Asiatic forts, situated on the Narrows, from the rear, would be a far more difficult undertaking than to occupy the hills of the Peninsula of Gallipoli. To begin with, these Asiatic forts cannot be commanded from the land in the same way as can the European defenses. Moreover, a force, disembarked from the Ægean, instead of being compelled to advance only a distance of about five miles, would have to undertake a march of at least twenty miles over an area of country in which no proper roads exist.

THE DEFENSES OF THE BOSPHORUS.

The length of the Bosphorus from the Seraglio Point at Constantinople to the mouth of the Black Sea is about nineteen miles. The breadth varies from 750 yards, just above Rumeli Hissar, to a little over two miles in Buyukdere Bay. The current sets from the Black Sea to the Sea of Marmora with an average speed of two and a half miles per hour, but opposite Rumeli Hissar a speed of five miles per hour is occasionally attained. Unlike the Dardanelles, the Bosphorus, which resembles a winding river, is bordered by picturesque wooden houses and by fine and stately palaces.

Almost throughout the length of the Bosphorus both shores rise immediately from the water's edge. In some places the coasts ascend to a height of little more than low hills, but in others the elevation reaches that of hundreds of feet, the highest levels being attained on the borders of the northern end.

The most important forts which defend the Bosphorus nearly all lie between Buyukdere in Europe and Beikos in Asia and the Black Sea entrance to the Channel—thus leaving the southern and thickly populated parts of the coast almost entirely undefended. The forts are extremely well hidden, many of them being so carefully placed that it is easy to pass up or down the Channel without becoming aware of their existence. Some are placed close to the water's edge, and some are on the slopes of the hills. Moreover, the defenses are so arranged as to cover the various more or less straight lengths, in such a way as to be able to fire upon ships alike before they reach, as they pass, and after they have passed them. But although during recent years much work has been done on the Bosphorus, there is no doubt, even if they had to be attacked only from the north, that the defenses of this area are much less strong and far less numerous than are those situated on the Dardanelles.

Owing to the existence of the Chatalja Lines, described in detail below, it would be difficult to take the forts on the European coast of the Bosphorus in the rear, or, more correctly, it would be necessary for a landing party to be disembarked somewhere within, that is, to the east of these lines.

On the Asiatic side, on the other hand, it might be possible to land troops from the Black Sea, and to march those troops to the high ground lying at the back of the Asiatic forts of the Bosphorus, forts which are practically, at no point, situated on the summit of the hills.

THE LAND DEFENSES.

Turning to the land defenses of the Ottoman capital, the geographical position of the city practically renders its protection on shore necessary from only one side. This is the case because Constantinople is situated on a sort of peninsula which is bounded on the south by the Sea of Marmora, and on the north by the Black Sea. This peninsula extends from the Bosphorus for about fifty miles in an almost due westerly direction. It gradually widens out from a breadth of about twenty-five to a breadth of about forty-seven miles, measured along a line extending approximately from Eregli, on the Sea of Marmora, to Midia, on the Black Sea.

The defences of this peninsula which protect Constantinople may be divided into two sections:

(1) The Constantinople Lines, composed of an inner and outer circle of earthen forts, which extend from the village of Makri Keui, on the Sea of Marmora, and about two and a half miles west of the ancient city walls, to Buyukdere, on the Bosphorus, and at a distance of about twelve miles from Constantinople. For some years these forts have been said to be out of repair and unarmed, and their power of resistance is but very small when compared to that of the Chatalja Lines.

(2) The Chatalja Lines, situated some twenty-five miles west of the city, extend across the isthmus, and form the principal land defenses. The front is narrowed on the south by Lake Buyuk Chekmedche—an inlet of the Sea of Marmora—and on the north by a lake called Derkos Gol, thus leaving a distance of some fifteen or sixteen miles which is protected by forts. Designed by von Bluhm Pasha, this line of defense was begun in 1877, when the Russian army was advancing on Constantinople. The natural position lends itself to the fortification of the capital; for as its flanks rest on the sea and on these impassable lakes, they cannot be turned. The forts, which number about thirty, have been constructed on a ridge of hills some 500 feet above the sea, across almost the entire front of which there runs a small stream, locally known as the Kara Su. The forts are built in two and sometimes three lines, and are so planned as to cover all the ground available for the advance of an enemy toward the capital.

In approaching a discussion concerning the actual state of the fortifications of the Dardanelles, the Bosphorus, and the Chatalja Lines, of the guns which they contain and of the men which are available to garrison them, it is extremely difficult to give any trustworthy details. While for many years it has been practically impossible for any outsider to visit these forts, we know that in recent times no stone has been left unturned to prepare them adequately to resist an attack. Since the Russo-Japanese war much has been done to improve the defenses of the Bosphorus. Moreover, throughout the Turco-Italian and the Balkan campaigns—during both of which the Ottoman government feared that an attempt might be made to force the Straits—the strength of the forts upon the Dardanelles was no doubt greatly increased. Again, from the moment when the Germans decided to drag Turkey into the war, it is certain that the enemy has turned his undivided attention to the defense of areas, the successful attack upon which is obviously destined practically, if not absolutely, to end the resistance of Turkey.

As no trustworthy details concerning the armaments of the three principal fortified areas of Turkey have ever been allowed to leak out to the public, it is only possible to accept the information already published by the Admiralty, concerning the guns in certain of the Dardanelles' defenses, as a proof that the strength of all these series of forts is probably much greater than has been anticipated by those who have grown to think of Turkey simply as a country in which corruption has prevailed, even from end to end of military affairs.

In regard to the garrisons located in or available for the defence of the Turkish fortified areas, it is, too, practically impossible to give any authentic details. Judging from information received from various private and reliable sources, I think that about 800,000 men were mobilized before or immediately after the outbreak of hostilities. Of these I believe that about 310,000 men were retained for service in Europe—an area now so small that it is comparatively easy to convey them from Adrianople to Constantinople or *vice versa*, as may be required. In addition, if no reinforcements have successfully been brought back from the Caucasus or from the Egyptian frontier, there are probably a further 120,000 men on the Asiatic sides of the Dardanelles and of the Bosphorus—one half of these being quartered in each area. If to these be added some 12,000-15,000 armed Germans, we must conclude that there is now a Turco-Germanic force of about 440,000 men available for the defence of the shores of the Dardanelles, the Sea of Marmora, and the Bosphorus.

Volatile Matter, Fixed Carbon and Sulphur in Coal

VOLATILE matter, fixed carbon, and sulphur, ordinarily do not enter into consideration in making contract specifications for the purchase of coal. Pound for pound, volatile matter, as a rule is likely to have quite as high or a higher heat value than the fixed carbon. Modern steam generating appliances should be able to burn one form as efficiently as the other. House heating appliances, however, utilize a relatively low proportion of the volatile material. In the main, this constituent distils off into the air with but poor or partial combustion, and appears at the chimney top in the form of black smoke. For these reasons the higher fixed carbon coals are better for domestic use than those high in volatile matter. Ash content, density, and sulphur also enter into the account.

Sulphur is present mainly in the form of iron pyrites, and is detrimental to the value of the coal, especially after its first stage of reduction to ferrous sulphide, FeS. This change occurs at relatively low temperatures, from 750 deg. to 900 deg. Fahr., and produces an easily fusible ingredient which promotes slagging and the formation of clinker. Sulphur is not without some virtue as a heat-producing constituent, however, but its value is low, having a little over one third of the heat of an equal weight of carbon and about one fourteenth of an equal weight of hydrogen. Sulphur may be a constituent of coal varying in amount from one to six per cent, and, because of its chemical form and properties, should be looked upon as an ingredient essentially different from the organic matter or real combustible material.—Bulletin 29, Illinois State Geological Survey.

Necessity for Mine Operators to Know the Ash Values of Their Coal

EVERY mine operator should come into possession of the data covering these values, and should develop a log of ash values for the various grades of output from his mine, if any attempt is to be made to submit bids in competition where guarantees as to ash values are required. If this knowledge were in hand, serious and very costly errors would be avoided in making contracts. For example, certain of the contracts with the Illinois State institutions for the fiscal year 1912-1913 guaranteed to maintain an ash content in screenings, "dry-coal" basis, of 12 and 13 per cent. As a matter of fact, the deliveries frequently ran as high as 20 and 21 per cent and entailed a penalty of 25 to 35 cents per ton. Some of these discrepancies are doubtless due to a lack of information on the part of the operators regarding the possibility of the earthy contamination which usually accompanies screenings.—Ill. State Geological Survey.

A New Type of Aeroplane

An "Even Keel" Flyer Embodying Many Original Features

By Thomas A. Edison Lake

THIS aeroplane is designed to fly on an "even-keel" and to have inherent stability, with flexible supporting surfaces which may be adjusted to permit vertical landing instead of the gliding descent as made by the present type.

As an aero-expression, the term "even-keel" designates a machine which maintains a horizontal position at all times, or in other words, without altering the fore and aft trim of the machine when ascending or descending.

The aeroplane shown in the illustration is the one upon which patent claims were recently granted and which embodies several new features, which I believe will be recognized as important improvements in the art of aerial navigation, particularly the feature which permits a vertical landing to be made when desired, or if forced by the stopping of the engine or by any other accident.

If a machine can be permitted to "settle" rather than glided to the ground, a safe landing can be made most anywhere, while a suitable place for a gliding descent is difficult to find, especially if the engine should stop while the machine was flying over a city or any other congested place where a gliding descent would be impossible.

New Lake aeroplane in full flight.

This type of machine will permit a more accurate dropping of bombs on fortifications and ships if this kind of warfare is to continue, because its headway can be entirely stopped for a sufficient length of time to permit the bombs to be dropped in a vertical line to the fortifications. Also the speed may be reduced to hold the aeroplane over a moving ship, which is to be attacked, so that the falling bomb would have the same headway as the ship and thus avoid the error due to the unknown and variable speed between aeroplane and ship.

Inherent stability is difficult to secure in a biplane or a monoplane, due to the shifting of the center of supporting pressure, which, as is well known, varies with the speed and the inclination of the fore and aft axis of the machine. The safety of this type of machine depends upon the constant manipulation of the horizontal rudders

FIG. I

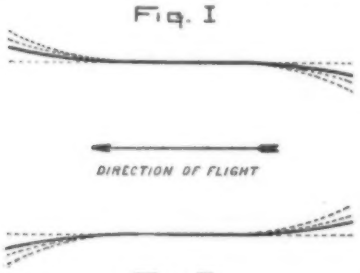


FIG. II

to prevent unexpected dives due to the lack of longitudinal stability.

A low center of gravity in a byplane or a monoplane has proven to be a disadvantage because of the pendulum-like motions which are set up due to the varying speed and resistances. Still, a low center of gravity is very desirable if the objectionable features can be eliminated, and I accomplish this by having a series of planes arranged in step-like order, so that each will have its own center of support which does not materially shift when the curvature of the planes are changed, either for variable headway or when making a vertical descent.

The slow, heavy machines of to-day have supporting

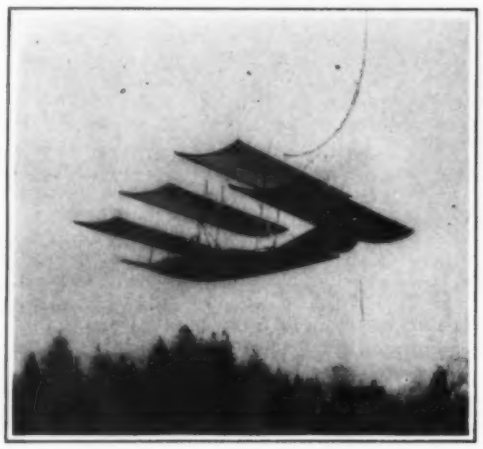


Fig. 3A.—Wings adjusted for vertical descent by a plane under headway.

planes of a very deep curvature, while the light, fast machines have planes of very slight curvature, or even perfectly flat planes, which shows that the lifting power of the plane is determined more by the curvature than by the angle of incidence. Also that the speed of the machine is controlled by this curvature as well as by the thrust of the propellers, and the machine of to-day with their fixed curvatures do not have the range of speed which would be possible if the curvature of the planes could be varied to suit the weight carried and the variable speed of the engine. Therefore, the greatest efficiency may be obtained by controlling the curvature of the planes during flight, in combination with the thrust of the propellers, because the simultaneous adjustment of the two will vary the lifting power of the planes, and hence control the climbing speed and the straight away flight, and thus permit of an easier landing at a greatly reduced headway.

I believe that one of the most important requirements of the flying machine is the ability to make a vertical landing. To accomplish this the machine must have a form of inherent stability so that it will fall right side up when headway is lost, and some means must be provided to check the speed of the fall and permit of a gentle landing.

As will be seen in the illustrations, the body of my type of machine is a streamline hull which is divided by bulkheads into several compartments, such as the engine compartment, the passenger compartment, etc. At the bow are located the horizontal trim rudders, which are used to counteract any tendency which may affect the fore and aft trim of the machine. These horizontal rudders have nothing to do with the control for causing the machine to ascend or descend, for which purposes they are used in the present type machines.

At the stern of the hull is a vertical fin to which is attached the balanced steering rudder. There are two propellers, arranged one on either side of the hull at the fore and aft center of the machine (which is the center of support and forward resistance) and below which is the center of gravity. These propellers are driven through a special transmission and clutch connected to the engine. The entire control system is very simple and quite similar to that of an automobile.

Arranged forward and aft of the center of gravity are the fuel tanks, an arrangement that provides a very effective method of maintaining a desired center of gravity, which would not be effected by additional weights being added, such as passengers and baggage. For instance: if the machine were perfectly balanced for flight and it was decided to take on an additional weight in the form of baggage or passengers, the center of gravity would not be altered, because if the additional weights were placed aft, a counteracting weight in the form of fuel would be forced from the after tank to the forward tank. The engine takes its fuel from a service tank, which would be supplied with an equal amount from each of the forward and after trim tanks.

Mounted in step-like order, on stanchions extending from the hull, are the main supporting planes. These supporting planes are constructed of flexible ribs so that the forward and rear edges thereof may be bent upwardly and downwardly in opposite directions or in the same direction, as may be desired, for the purposes as will be hereafter explained.

From a cursory glance one would think that the control of these flexible planes involved much complication, but I have provided a very simple mechanism which simultaneously controls all of the planes from a single operating lever having a locking device which will hold the planes to any adjustment desired. This control mechanism is so balanced that very little power is required to operate it. The curvature of the flexible planes can be adjusted to any c[illegible] the forms now in use, as well as other forms which may be desired. I believe

Fig. 3B.—Wings adjusted for vertical descent by machine at rest.

the form as shown in Fig. 1 of the wing diagram will be the most efficient, and any degree of curvature may be had from a flat surface to a deep curvature for lifting power. The adjustment as shown in Fig. 2 would seldom be used because gravity will cause the machine to descend fast enough, but there may be a time when it would be

FIG. III

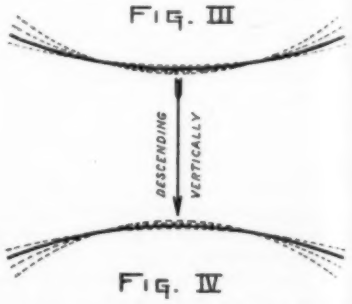
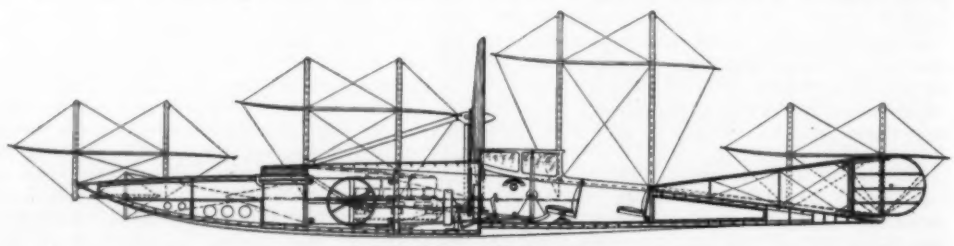


FIG. IV

desirable and necessary to make a sudden swoop downward to avoid a collision with another machine, or any other cause which would call for a hasty descent. By a very simple setting of the control mechanism the planes may be adjusted so that only the forward or rear edge of each plane will be curved, while the rest of the plane remains as set. Also the mechanism may be adjusted so that either the forward or rear edge of the plane may be given a greater curvature in proportion to the oppo-



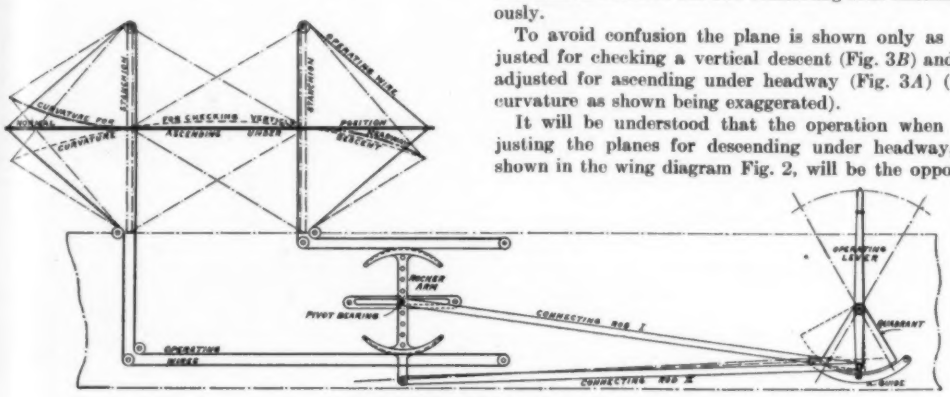
Vertical sectional elevation.

site edge. When at rest the normal position of the planes would be flat.

In operation the control of the planes will be as follows: When starting flight the greatest lifting power possible is desired so that the machine will leave the ground or water with the least amount of headway, and with the shortest run possible. To accomplish this the planes are given their maximum curvature, and the propellers run at their highest speed. When the desired altitude is attained the curvature of the planes will be reduced to give just the proper amount of support for straight away flight. If a gliding descent is to be made, the curvature would be reduced to give the proper gliding angle, and when the machine is at a proper distance from the ground or water the planes would be given their maximum curvature and thus act as a brake to the forward momentum and permit a gentle landing.

When making a vertical descent the forward momentum would first be eliminated by stopping the propellers and giving the planes their greatest curvature. This would cause the machine to climb very rapidly for a short distance until the forward momentum was spent, at which point the planes would be adjusted as shown in Fig. 3, a form which gives the machine inherent stability, allowing it to "settle" right side up. When near the ground or water upon which the landing is to be made, the planes would suddenly be reversed as shown in Fig. 4. By thus reversing the planes, the falling speed is checked about half and the planes act as parachutes, forming an "air-cushion," so to speak, which permits a gentle landing.

By referring to the sketch, "Wing Control Diagram," it will be seen that the operation of the flexible planes are quite simple. In this diagram the dot and dash line



Wing control diagram.

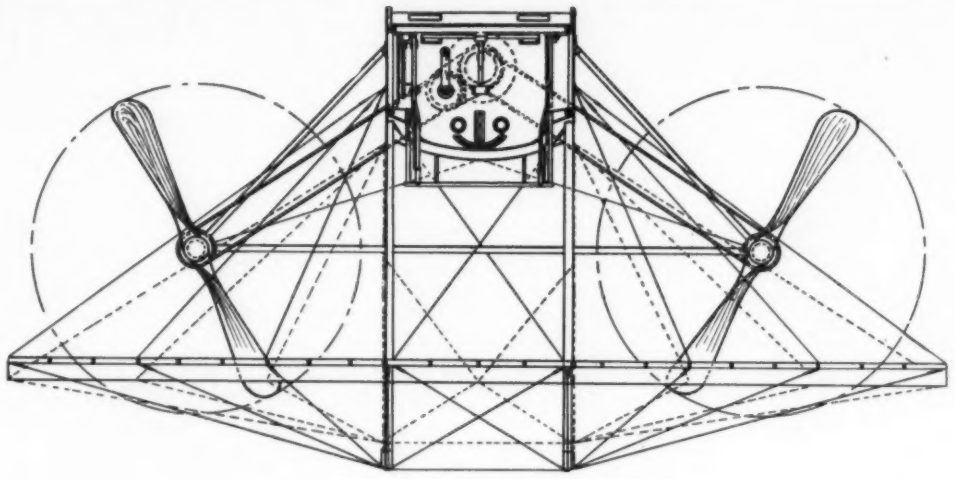
represents the hull or body of the machine, upon which are mounted the stanchions which support the plane.

Normally the plane is flat, as shown by the double line, and is connected by the wires over pulleys to the rocker arm whose bearing is slidingly retained in the guide bearing. Connected to the rocker arm bearing is a connecting rod *I* which is also connected to the quadrant which is held from moving by a locking pin (not shown).

Connected to the end of the rocking lever is another connecting rod *II*, whose other end is connected to the operating lever. Below the operating lever is a guide which keeps the lever in contact with the quadrant when it is desired to move the two connecting rods simultaneously.

To avoid confusion the plane is shown only as adjusted for checking a vertical descent (Fig. 3*B*) and as adjusted for ascending under headway (Fig. 3*A*) (this curvature as shown being exaggerated).

It will be understood that the operation when adjusting the planes for descending under headway, as shown in the wing diagram Fig. 2, will be the opposite to the adjustment for ascending shown in Fig. 1. Also that the operation, when adjusting the planes for inherent stability, as shown in Fig. 3 of the wing diagram, will be just the opposite to the adjustment as shown in Fig. 4 of the wing diagram and the dotted line of the wing control diagram.



Cross section at center of length.

When adjusting the plane for ascending, as shown by the heavy dot and dash line, the rocking arm will pivot at the bearing shown, which will be held from sliding forward or backward by the rod *I* connected to the quadrant, which is held as though solid by a locking pin (not shown).

Thus by pushing the control lever forward to the point designated by the dotted center line, the rocker arm will pivot at its bearing, assuming the angle shown, pulling down the rear edge of the plane and elevating the forward edge respectively.

When adjusting the planes as shown by the dotted line the operating lever will be brought to its neutral position so that the lug on the lower end of the lever will pass through the opening in the guide, and thus engage a clutch on the quadrant, at the same time releasing the locking pin. Now the operating lever and the quadrant may be moved simultaneously forward or backward. When the lever is pulled back to the position designated by the center line, the quadrant is moved with it, and the two connecting rods *I* and *II* are simultaneously moved forward, which in turn push the rocking arm vertically forward along the guide bearing.

Thus it will be seen that both the forward and rear edges of the plane will be simultaneously pulled down through the wires. By moving the bearing of the rocking arm and the guide bearing up or down, the relative curvature of the forward and rear edges of the planes may be varied.

It will be understood that all of the planes will be suitably connected to the rocking arm.

German War-Driven Scientific Progress

THE extent to which the war has been the cause of scientific progress in Germany is cogently emphasized in a communication, from the director of a large German metallurgical company to a correspondent in New York, which the *Engineering and Mining Journal* recently published, and for the reliability of which it vouches. The important points follow:

Means have been found to manufacture gun and rifle cartridges and the fuse heads of grenades without copper or brass. Soft iron, having a small copper content, and zinc, treated by a special process, are made to replace to a large extent copper and brass.

Realizing that the prolongation of the war may result in a shortage in aluminium, though the chief raw material for the manufacture of this, beauxite, comes from northern France, a Heidelberg chemist has discovered an apparently rational process for recovering aluminium oxide from ordinary clay containing about 30 per cent Al_2O_3. The process also provides for the simultaneous extraction of the alkalis, particularly potash. Two aluminium factories will soon be completed and will make Germany independent of foreign countries as to this metal.

Attention is being given to the substitution of magnesium for aluminium. It has been shown that metallic magnesium, and particularly a magnesium-aluminium alloy, may possibly replace copper as an electrical conductor. Another large magnesium plant is being erected to use the large quantities of magnesium chloride which are a by-product of the potash industry, hitherto considered worthless.

England having cut off the supply of gasoline and petroleum, and although benzol will satisfactorily replace the former, two synthetic processes have been worked out for producing gasoline which will play a large role in the future. A process for making gasoline from mineral oils has been simplified and a large plant will soon be operating. A second new gasoline manufacturing process has been invented by a professor in a prominent technical school, based on the assumption that if hydrogen be added to unsaturated hydrocarbons, gasoline will be formed as in nature. Bituminous coal being regarded as unsaturated hydrocarbons, it is proposed to add hydrogen to these and make gasoline, a new plant for which is expected to be in operation soon. Petroleum is being replaced by acetylene, which can be burned in safety lamps more cheaply.

To offset the shutting off of the supply of saltpeter or Chilean nitrates and thereby the manufacture of important explosives, very large works are being erected to convert the nitrogen of the air into ammonia and this into nitric acid by the contact process.

Sulphuric acid having become so expensive, ammonium carbonate made by the Haber process is permitted to come in contact with gypsum, which by a complete reaction forms ammonium sulphate and calcium carbonate. Germany's large deposits of magnesium sulphates are to be similarly used. Also by decomposing magnesium or barium sulphates with coal the sulphide is formed which is further decomposed by carbonic acid into barium carbonate and hydrogen sulphide, which by suitable combustion is transformed into sulphurous acid or sulphur. The sulphuric acid made from this is exceedingly pure and the supplies of barium sulphate are enormous.

Tetanus Serum for the French Army

ONE of the important problems which have arisen since the war is the preparation of serum for the treatment of tetanus. Of all the complications to which wounded men are exposed, the ones most to be feared are tetanus and gaseous gangrene, and especially the former, for once it has set in there is little chance that the patient will survive. For this reason there were numerous fatal cases in hospitals and ambulances which were due to wounds of a slight nature at the outset. Especially in the trenches, wounded men are often under the worst conditions as regards contamination of wounds, and during a battle are obliged to remain for long hours before receiving any aid. It is well known that tetanus is due to a special microbe known as bacillus of Nicolaier, and like the diphtheria microbe, it gives rise to a violent poison. Although the bacillus itself may be confined to the wound, the toxine quickly circulates through the entire system. The microbe is oftenest found in the humus of the soil, and some regions are noted as especially dangerous, one of these being precisely the region of the Marne where so much fighting took place. To treat this disease there is employed the anti-tetanic serum due to Roux and Vaillard, but unfortunately its effect is hardly curative but only preventive. Should the patient be inoculated within due time after being wounded, he has a good chance, from 50 to 95 per cent according to the case, to recover, so that Prof. Landouzy advocates inoculation of all suspected wounds, which would practically mean the treatment of all the wounded from the battlefield. Since the war, the Pasteur Institute has been very active in preparation of the serum, and took measures to increase the number of horses which furnished the serum; it was also able to reduce the time needed to produce the serum from five months to two months. Each horse in normal state furnishes 12 liters of blood in one week or 3 liters of serum, making 300 doses of 10 cubic centimeters, after which the animal reposes for the following week. The production of the serum is therefore not continuous from the same animal. In November the Institute was able to furnish no less than 150,000 doses of serum, at the same time with other varieties (anti-diphtheretic, anti-dysenteric, etc.). The horses for all these purposes are located at Paris and in suburban establishments, as well as at the Toulouse Veterinary School.

Photo-Electricity—I*

The Intimate Relations of Light and Electricity

By Prof. J. A. Fleming, F.R.S.

In opening a course of two Tyndall lectures on "Photo-electricity," at the Royal Institution, Prof. J. A. Fleming, F.R.S., remarked that the phenomena of light and of electricity were so closely connected that the study of all of them might truthfully be said to be embraced within the confines of one branch of science. The term "photo-electricity" was, however, reserved to describe a special effect—viz., the power of light of certain kinds, particularly ultra-violet light, to cause a discharge of negative electricity from certain substances. That effect had a very important connection with the problem of the nature of light, and also with certain very practical questions of radiotelegraphy.

The starting-point for this knowledge had been an observation made by Hertz in 1887, that the light from an electric spark falling on other spark-balls assisted the discharge to take place between the latter. In demonstrating this effect, Prof. Fleming made use of two pairs of balls in parallel between copper strips; the lower pair was in a glass box; the upper pair was not encased, but the gap was too large to allow the spark to pass until the gap was illuminated by certain sources of light—viz., a spark between two invar terminals (rich in ultra-violet rays), an arc-lamp, and a burning magnesium wire; ordinary visible light had little or no effect, a candle none. When a screen of glass or mica was interposed in the beam, the discharge was stopped; a quartz screen did not stop the discharge. Hertz rightly concluded that the effect was due to ultra-violet rays. A year later Hallwachs discovered that ultra-violet rays had the power of discharging negative electricity (not positive) from plates of zinc or aluminium, provided the plates were clean and well polished. For this demonstration Prof. Fleming used a new, exceedingly simple electroscope of his own, consisting of a slightly bent brass pillar little more than an inch high, from which a narrow rectangle of aluminium foil was suspended by two short silk threads, kept damp by calcium chloride; the pillar stood on an ebonite insulator, and was soldered to a long wire ending in a ball, to which the electric charge was applied; the whole electroscope, which does not require any glass case, was only a few inches in height. The plates to be examined were placed upon an insulating stand and joined to the electroscope; the one side of each plate was polished, the other dull. When the bright side of the negatively-charged plate faced the beam of an arc-lamp, the electroscope was discharged, and the effect was improved by interposing an earthed wire-gauze grid between the plate and the arc, but was stopped by a screen of glass. The effects were weaker or absent when the dull side of the plate was illuminated and when the charge was positive. For another arrangement of the experiment, however, it was preferable to start with a positive charge. In this case, the insulated grid, joined to the electroscope and charged positively, was placed behind the illuminated zinc plate; when this zinc plate was earthed, the positive charge of the grid was seen to disappear. Similar effects were obtained with plates of aluminium and magnesium, but tin and silver proved much less photo-electric; and it was thus shown that the effect depended both upon the nature of the plate and upon the state of its surface. For the further study of the phenomena Prof. Fleming had devised an apparatus comprising a wooden box divided into an upper and a lower compartment: in the upper was a spark-gap of invar electrodes, below it a quartz window, and below this a table for the disk of metal,or a tray containing compressed powder of graphite, galena, etc.; this table was surrounded by a metal ring which was charged positively and joined to the electroscope.

The explanation of the rather complex phenomena, Prof. Fleming continued, was that light (especially ultra-violet rays) caused the emission of negative electrons from certain substances; these substances then assumed a positive charge, and the effect would stop itself by the accumulation of the positive charge, unless the plate were earthed. Hence the plate was generally earthed in the experiments, and the photo-electric current measured was due to the escape of the negative electrons and to the neutralization of the positively-charged ring (or grid) joined to the electroscope. When experiments were conducted with such apparatus, the metals and also compounds could be arranged in photo-electric series; but the orders had not much scientific value, as much depended upon conditions. Oxides were not photo-electric as a rule, but sulphides were strongly active. Thus powdered galena (lead sulphide) became very highly photo-electric under a pressure of 50 tons per square inch, while graphite (plumbago, which resembled galena in appearance) and molybdenum sulphide were practically non-photo-electric. It was soon observed in such experiments that the effect rapidly decayed with time. It was customary to speak of "photo-electric fatigue;" but the term was not well chosen, for this fatigue could not be cured by rest simply; the metal had to be re-polished. Zinc lost half of its sensitiveness in 5 minutes, and in many substances the sensitiveness dropped to 10 per cent in two days. The fatigue took place in air and also in hydrogen, but not in a high vacuum, and seemed to be due to the formation of a gas film on the surface. Exact experiments should therefore be made in a vacuum and by condensing metallic vapors in a vacuum. In this way Llewellyn Hughes (Cambridge) had in 1915 arrived at the following photo-electric series for metals and for other substances—metals: Rb, K, Na, Al, Mg, Zn, Sn, Cd, Pb, Bi, Au, Ni, Cu, Ag, Fe; and sulphides: Pb, Cu, Mn, Ag, Sn, Fe, Ni, Sb, Sv, Zn, Cd, Co, Mo.

Experiments by Hughes and others had also established the following laws: (1) For every substance there was a certain limiting frequency of light os illation necessary to produce the photo-electric effect—i. e., light of smaller frequency would not produce it. (2) The more electro-positive the substance, the smaller this frequency; for the alkali metals, visible light sufficed (ultra-violet light of higher frequency not being needed in that case). (5) When the metal was uninsulated the positive potential which was reached under the influence of light of frequency n was proportional to the difference between n and the limiting frequency n_0. (4) The photo-electric current (or number of electrons discharged per second) was proportional to the intensity of the light. (5) The maximum velocity of the electrons emitted was independent of the temperature and the intensity of light.

Some of these effects Prof. Fleming demonstrated with the aid of the liquid alloy (resembling mercury) consisting of atomic proportions of potassium and sodium. The cell used was a wide glass tube, provided with a central structure. The one end was filled with the solid metals; in the other end a horizontal strip of platinum foil was fixed, and wire terminals were fused into the glass; the tube was afterward evacuated, sealed, and the alkali metals were fused, so that the liquid alloy in flowing through the stricture collected in a well under the platinum, being separated from it by the evacuated space. A galvanometer and the negative pole of two Leclanche cells were joined in series to the alloy. When the alloy was illuminated by the arc, a copious stream of electrons was given off; a screen of blue glass did not in this case stop the effect, because visible light is sufficient for the alkali metals, but a screen of red glass did stop it. It was also demonstrated that the photo-electric effect depends upon the plane of polarization (Elster and Geitel). A ray of light, Prof. Fleming explained with the help of a card model, consisted of electric and magnetic displacements at right angles to one another, both in the plane of the wave-front. If these electric and magnetic forces remained in the same constant planes, passing through the ray direction (which they did not under ordinary conditions), the light was said to be plane-polarized, the plane of polarization being the plane of the magnetic force. When now light polarized by a Nicol prism fell at an angle of 65 degrees on the surface of the alloy, it was found that the photo-electric effect was greatest when the electric vector was in the plane of incidence; that is to say, when the light was polarized in a plane at right angles to the plane of incidence, or when the electric force in the ray had a component normal to the surface of the alloy, because in that case the force assisted the extraction of electrons. The photo-electric current from the alloy had a maximum for a wave-length near the end of the visible spectrum when the light was polarized, as mentioned (electric vector in plane of incidence), but it increased with decreasing wave-length for light polarized so that the electric vector was at right angles to the plane of incidence. Hence for polarized light a normal (minimum) effect and a selective (maximum) effect had to be distinguished. This point will again be alluded to.

Reverting to the photo-electric power of compounds, Prof. Fleming stated that the activity of oxides was mostly not large, though the mineral zincite (oxide of zinc) was more active than the powdered oxide. The sulphides, on the other hand, were very active, especially in the form of minerals, galena and chalcopyrite (the double sulphide of iron and copper) being superior to metals in this respect. There was, further, a close connection between phosphorescence and photo-electric activity, phosphorescent sulphides (of barium, calcium, etc., Balmain's paint) being also photo-electric. But that parallelity did not necessarily apply to fluorescence, although bodies like anthracene, fluorescein, willemite, showed both effects (fluorescent and photo-electric) strongly. These fluorescent bodies appeared greenish when reflecting (invisible) ultra-violet illumination, as was shown with the aid of invar sparks, but in transparent light the fluorescein solution was orange-colored, and a solution of quinine sulphate (which fluoresced bluish) was colorless. The fluorescence disappeared with the source of light, while the phosphorescence persisted for some time after the illumination had been cut off. According to Pauli and Volmer, the radiations which produced fluorescence were not identical with those which produced photo-electricity.

The next question to be studied was: Which were the particular electrons escaping in photoelectricity? According to the electronic theory, metals conducted the electric current because they contained free electrons, as numerous as the atoms, moving to and fro between the atoms at velocities of about 60 miles per second, in all directions, unless directed into a stream by an external electromotive force. Now light did not affect the conductivity of metals because, it was thought, the number of free electrons was too large and their mean free paths too long. Light did increase the conductivity of selenium, however, and also that of the silver halides (chloride, bromide, iodide), and Prof. Fleming considered the unilateral conductivity of certain substances, which were utilized as rectifying detectors in radiotelegraphy, as very suggestive in this connection. It was striking that in the favorite contact-detectors for wireless telegraphy, such as chalcopyrite-zincite, galena-plumbago (apparently used by preference in the German navy), copper-molybdenite, and steel- arbon, the one substance of the pair (the first mentioned) was highly photo-electric, and the other not. To demonstrate this Prof. Fleming made use of the curve-tracer which he described recently before the Physical Society.[1] When the zincite was joined to the negative pole of the battery a large current was seen to flow, not when the polarity was reversed. Now the electro-negative metals and also zincite were full of electrons, but were reluctant to give them up, while the electro-positive metals potassium, etc., and the chalcopyrite, readily gave up their electrons; the zincite might hence be called an electro-negative compound. When an electro-positive and an electro-negative compound came into direct contact, the electrons tended to pass from the former to the latter until the crowding of the electrons stopped the flow, and when it was attempted to urge the electrons across the junction by the aid of an external electromotive force, it was found more difficult to force them into the electro-negative than into the electro-positive body. Hence resulted an unsymmetrical conductivity, and the fact that the largest current flowed when the zincite (already crowded with electrons) was the negative pole meant that it was more easy to expel electrons than to draw them in. One might think of a room full of people next to an empty room; the rush would be toward the empty room.

Coming, finally, to the explanation of photo-electricity, Prof. Fleming said that resonance had first been thought of. If any of the loose electrons circulating round an atom had an oscillation imposed upon them by the light-waves, then the amplitudes of the oscillations might increase until the electrons could break away. Such a resonant effect seemed, indeed, to take place in the selective photo-electric effect of the potassium-sodium alloy, which had a maximum for a certain wave-length near the violet end. But the explanation could not hold generally for the normal photo-electric effect, which was not due to light of any particular frequency, but was produced by rays of all frequencies above a certain frequency. Then a trigger effect had been suggested, the light being merely supposed to start the action. But consideration of the energy required to pull out an electron did not support that suggestion. The work required for this purpose was something like a billionth of an erg. Now 13½ million ergs were equivalent to a foot-pound; when a candle illuminated a white surface at a distance of 1 foot, the energy delivered against that surface (1 foot-candle) was 200 ergs per square centimeter per second, and 1 erg per square centimeter per second was estimated to be strong enough to produce a sensible photo-electric effect. Further, the diameter of an atom was of the order of 10^{-8} centimeter, the apparent area of the atom was 10^{-16} square centimeter; light energy of 1 erg per square centimeter per second therefore would have to act on an atom for about 1,000 seconds before an

* From *Engineering*.

[1] See *Engineering* page 431.

electron would be delivered. But the liberation of the electrons seemed to be instantaneous in experiments.

To help over this difficulty it might be assumed that the light energy was not uniformly distributed and concentrated either as to space or as to time. Taking up an idea of Faraday, J. J. Thomson had suggested that the energy of the wave-front was concentrated in specks or spots, while Continental physicists taught that light was not emitted in a uniform stream, but in bundles (quantum theory), the bundles being indivisible and containing energy proportional to the frequency. On either of these two assumptions, the local or momentary energy might be larger than the mean energy; such views would explain the photo-electric effect, but the quantum theory —which recalled the corpuscular theory—would not account for interference phenomena. The position was thus this: The Maxwell theory explained interference, diffraction, polarization, and most other optical phenomena, but it failed to explain the photo-electric effect, which seemed to demand some form of atomic structure in a ray of light, and indeed a re-consideration of the whole subject of radiation. Huxley had once said that the great and ever-recurring tragedy of science was that of a beautiful hypothesis killed by an ugly fact. Yet facts had to be given every opportunity to multiply themselves, so that they might prevent scientists from encouraging the growth of hypothesis which, as Bacon had said in his "Novum Organum," were only idols of the theater and the den. The second lecture, Prof. Fleming remarked in concluding, would discuss the action of light on gases and some kindred questions on radiotelegraphy.

(*To be concluded.*)

Kilns for Lime Burning

PRACTICALLY all of the lime produced in this country to-day is burned in some form of kiln. What is known as the shaft kiln is used almost universally, although a few attempts have been made to adapt the rotary kiln, so well known in the cement industry. The rotary kiln, although it has many advantages over the shaft type, has the one great disadvantage at present, that the stone must be crushed to a fine size. Therefore the product is not salable as lump lime and can be used only for hydration. The manufacture of hydrated lime is a comparatively new industry, but is growing very rapidly, so that the use of the rotary kiln is fast gaining in favor.

This paper deals only with the shaft kilns, of which there are a great many varieties. In general, a shaft kiln resembles a short, wide stack, of either square, round, or elliptical cross section. It consists of a casing of steel or stone which is lined with refractory material. The long, vertical chamber formed by this lining may be divided into three compartments by imaginary horizontal planes. The top compartment, called the hopper, is used for storing and preheating the stone. Its sides slope in so that the stone may slide down into the middle compartment, the shaft. This shaft is the place where the lime is burned. It may be of either square, round, or elliptical cross section, independently of the outside of the kiln. Generally the sides of the shaft are vertical, although in some cases they slope outward. In this latter method of construction it is customary to omit the hopper. At the bottom of the shaft the third compartment (the cooler) is used for storing the lime after it is burned. The top of the cooler must, of course, have the same cross section as the shaft. The sides are drawn in to form a slide leading to the drawing door. A hole in the side or bottom of the cooler is closed by a door or by sheets of iron which swing on a pivot and are known as shears. The lime is removed through this opening. The fuel used in burning the lime is consumed in the fire boxes usually arranged on two sides of the kiln. They are very similar to the common fire boxes in use under boilers. Each kiln has two or more, which are set in openings through the casing and lining into the lower part of the shaft. In this paper the level of the grates in the fire box will be considered the bottom of the shaft, it being assumed that lime is not burned below this point. When gas is used as the fuel, the fire box is a mere port through which the gas pipe is led into the kiln. In either case the draught caused by the combustion of the fuel draws the flame up through this shaft in direct contact with the lime and stone and the gases formed pass out at the top of the hopper. To increase this natural draught a stack is sometimes placed on top of the kiln. Forced or induced draught, or a combination of both, is also in common use. The forced draught is generally created by blowing steam through the grates into the fire box; the induced draught by drawing the gas out through the top with a fan. These two methods may be combined, or the gas which is drawn from the top may be forced back through the grates, according to the Eldred process. These methods of increasing the draught have in some cases necessitated closing the top of the kiln. Hence, a charging door must be supplied through which the stone can be dumped.

There are many considerations which limit the practical size of a kiln. Chief of these is probably the market which the kiln has to supply. Lime is a perishable article, hence any cessation in the demand necessitates a curtailment of the supply. If the market demands a definite supply of lime for a continuous period, a kiln can be built large enough to supply that demand. Generally, however, it is safer to build a number of small kilns, so that if the demand falls off, it will not be necessary to close the entire plant. Recently the custom has been introduced at a few plants to run the kilns at full capacity and to hydrate what lime can not be used immediately; for hydrate may be stored. The cross section of the shaft is limited by the distance the heat can be made to penetrate toward the center. The total height of the kiln above the grates is limited by the conditions of the draught. If natural draught is used, the gases must leave the top of the kilns hot enough to produce the draught. That is, the kiln must not be too high, or the stone will absorb too much heat from the gases. With any form of induced draught the kiln should be just high enough for the gases to leave it approximately at the temperature of the external air.

What is perhaps the simplest type of kiln recognized by modern practice might be constructed as follows: An outer casing or shell is built up of sections of steel rolled to shape and bolted together, so as to form a stack, say, 10 feet in diameter by 30 feet in height. Inside of the casing, and concentric with it, is erected another stack of fire brick. This may be cylindrical in shape, 6 feet inside diameter by 30 feet high, with walls 18 inches thick. The annular space between the fire brick and the steel is filled with ashes, brickbats, or other similar material, which acts as an insulator to prevent loss of heat by radiation, and which also serves to take up the expansion of the fire brick. Two openings in the fire brick stack, opposite each other and about 3 to 5 feet from the bottom, form the inner ends of the fire boxes. These fire boxes extend out horizontally through the steel casing. They are of the ordinary type used for boilers and may be, for example, 4 feet long (from the outer door to the interior of the kiln) by 3 feet wide by 2 feet high (from the grate bars to the top of the arch). The kiln as described is supported on what is known as the firing floor. The bottom of the kiln is closed by a conical steel chamber, known as the cooler, which is hung under the firing floor. This cooler may be 6 feet in diameter at the top by 18 inches diameter at the bottom by 4 feet high. The bottom is closed by the shears previously mentioned and is generally 4 or 5 feet above the cooling floor, so that a wheelbarrow can be placed under the cooler to receive the lime as it is drawn out of the kiln. A kiln of this type, when used to burn a dense high-calcium stone, with a good grade of gas coal, will have a capacity of 8 to 10 tons of burned lime per 24 hours.

The design as given is subject to a great variety of modifications. The form, the dimensions, and even the materials, may be changed to meet the peculiar requirements of each plant. Thus, if it is desired to increase the natural draught, a stack may be mounted on top of the kiln. This stack should be connected to the shaft by a conical chamber, so that the gas is not compelled to turn sharp corners which would tend to set up eddy currents and reduce the draught. The size of stack must be so selected that there will be no tendency to throttle the gas. Its dimensions can be calculated by the ordinary formulas for chimney design. For the kiln as described, under ordinary conditions, a stack 20 inches in diameter will have sufficient capacity and will add one eight inch of water to the draught for every 35 feet of height.

The casing of the kiln is sometimes built of stone or concrete instead of steel. These materials probably diminish the amount of heat lost through the kiln wall, but the casing should be designed primarily for strength. Most of the strain is found to be lateral, which tends to push the stone out. It is resisted much better by steel. Reinforced concrete, when properly designed, should combine the strength of the steel with the heat insulating properties of the stone, and is therefore finding favor in modern construction.

The shaft of the kiln may be built of material other than fire brick. In the burning zone, or that part of the shaft extending 8 or 10 feet above the grates, the brick are subjected to a high temperature (2,200 deg. Fahr. to 2,600 deg. Fahr.) and also to the fluxing action of the caustic lime. In the upper part of the shaft the temperature is low, and the wear is caused mainly by abrasion. A good grade of fire brick will stand the former condition pretty well, but is too soft to resist the abrasion. For this reason the upper part of the shaft is frequently built of cut granite, sandstone, paving brick, concrete, or some equally hard and cheap material. Even a good fire brick in the burning zone will wear out in time, owing to the fluxing action of the lime. It has recently been found that silica brick give longer service under some circumstances.[1]

The upper part of the shaft is frequently enlarged to form a hopper. This practice is to be commended, because it gives an opportunity to store a supply of stone, so that the kiln can be operated for a day or two independently of the quarry. Moreover, this stone is stored in such a way that it is preheated, and it requires no further handling. If the kiln has a capacity of 10 tons of lime per day, the hopper should hold 27½ cubic yards of stone, or two day's supply.

The shape of the cross section of the shaft need not be circular, but may be square, rectangular, or elliptical. When the products of combustion enter the kiln from the fire boxes they tend to pass upward immediately, along the walls of the shaft. The shaft must be designed so as to force them to penetrate as far as possible toward the center of the kiln. If the shaft is square or rectangular, the corners will form chimneys through which the gases can escape. Obviously, an elliptical shaft gives a larger area with the same distance between the fires than a circular shaft, and this larger area is the cause of increased capacity. The elliptical shaft is, therefore, the most economical of the four when the capacity of the kiln and the uniformity of the product are considered. The other shapes are frequently used, because they are much cheaper to build and repair. The objections to the circular shape can be overcome by the use of three or four fire boxes instead of two.

The cooler is sometimes lined with fire brick. This retains sufficient heat to complete the calcination of any stone which may have passed through the kiln unburned. The advantage of this process is doubtful, because it necessitates drawing the lime out of the kiln while it is still hot, with the attendant difficulties of handling it.

There are two methods in common use for operating lime kilns, which are known as the "following" and the "sticking" processes. By either process only a part of the lime is taken out at a time, since enough must remain to fill the cooler and so keep the unburned stone above the grate level. The "following" method is very simple. When the lime is drawn from the bottom of the kiln the remaining lime and stone slide down and fill up the space, as would naturally be expected. The difficulty with the process lies in the fact that the stone will not burn evenly. Owing to the tendency of the flame and hot gasses to pass up the side of the shaft, rather than to go into the center, the mass of unburned stone always extends down further in the center than at the sides. It is obvious that if the stone falls down evenly, the unburned portion in the center must be brought below the grate level before the burned lime at the sides can be removed from the burning zone. It is the custom to draw out enough lime so that the lowest part of the stone will reach to about the grate level and then take a chance on overburning the lime in front of the fires.

The difficulty just explained may be obivated by the use of the "sticking" process. In this the kiln is generally chilled by omitting to fire and leaving the fire doors open for from 20 minutes to 1 hour before drawing. This chilling causes a contraction of the lining and also a solidification of the fused compounds resulting from the action of the lime on the lining. When the lime is drawn from the cooler these two processes acting together prevent the stone from following and cause it to "stick" or "hang." After drawing the lime is knocked down by bars inserted through the fire boxes, and finally the whole mass is caused to fall by knocking the supporting pillar of lime away. By this method the lime can all be removed from the burning zone and an even layer of fresh stone is presented to the fire. It has great disadvantages, however. It requires altogether from half an hour to an hour and a half to complete the drawing, during which time no lime is burned, labor is expended, and the kiln is cooling down. Consequently it is extravagant in time, labor, and fuel.

It must not be supposed that there is a hard and fast distinction between "following" and "sticking" kilns. In general, it may be said that if the sides of the shaft slope outward; that is, if the diameter is larger at the fire than at the top of the shaft, the kiln will "follow;" if straight, it will "stick." A skilled fireman can usually operate any kiln by either process, but sometimes kilns designed to "follow" will "stick," and vice versa. "Following" kilns also have a troublesome habit of "turning over" at times. That is, something will cause a quantity of lime to stick in one part of a kiln while the stone falls down past it, with the result that a layer of lime remains above some unburned stone.

To summarize, the "following" process is probably more economical of fuel, labor, and time than the "sticking" process. But, owing to the less danger of obtaining overburned or recarbonated lime, the "sticking" process probably yields a larger output of more nearly uniform quality. The relative values of the two processes have not been definitely determined.—*Mineral Resources of U. S., 1913, Part II, U. S. Geological Survey.*

[1] Seaver, Kenneth, Limekiln linings: Nat. Lime Mfrs. Assoc. Trans., 1914.

Illustrated London News

Turkish village of Kum Kale on fire from bombardment.

Photo by Mearlon

English fishing boats, used as mine sweepers in the Dardanelles.

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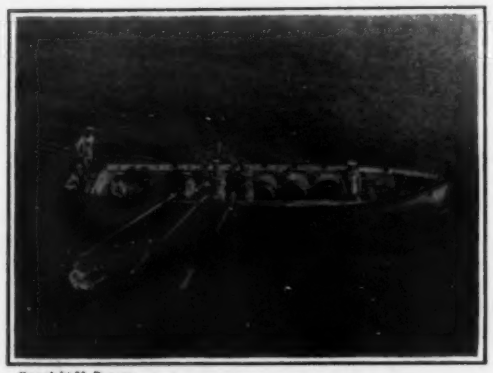
Coaling a French battleship in the Dardanelles.

Illustrated London News

Bombardment of Turkish fort, seen from a ship of the fleet.



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French sailors laying mines in the Dardanelles.

Fortnightly Review

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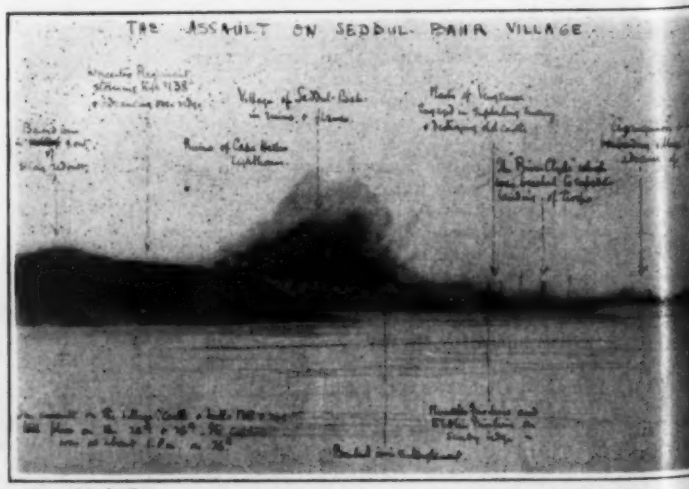
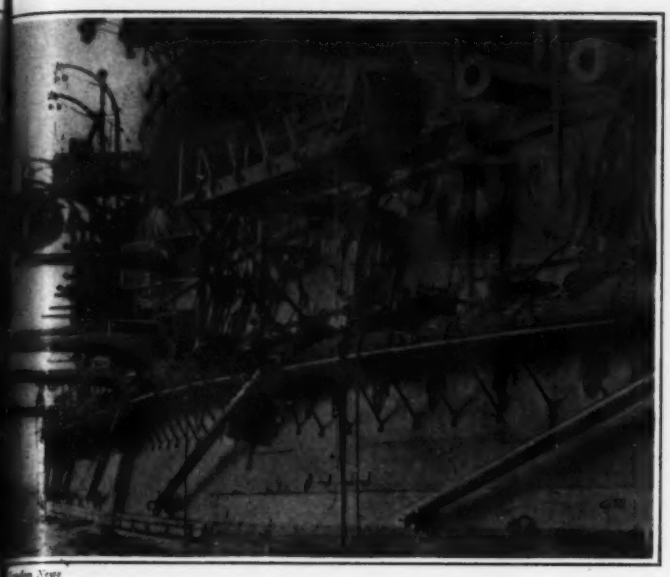


Illustrated London News

Transport "River Clyde" run ashore to land troops at Seddul-Bahr.

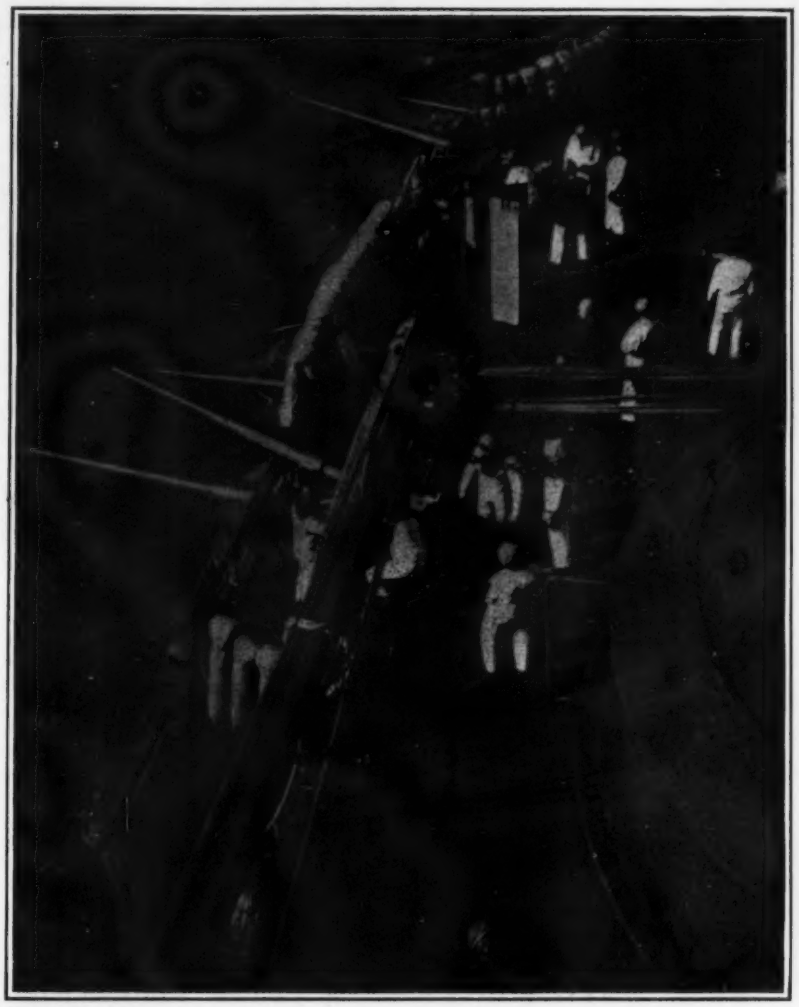
WITH THE ALLIED

LIBRARY Southern California



Illustrated London News

Secondary battery of British cruiser "Vengeance."

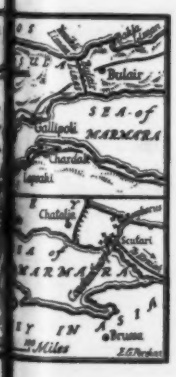


Illustrated London News

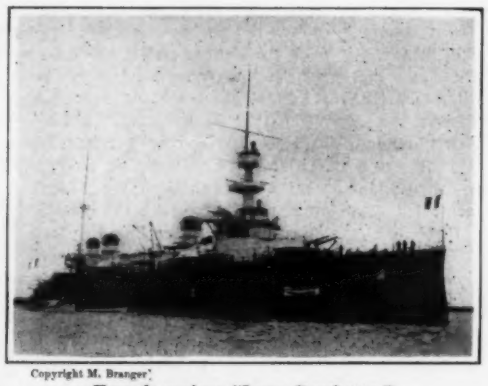
Gun crews of French ship "Charlemagne" wearing anti-concussion caps.

M. Branger

French troops on a transport in the Dardanelles.



ardanelles.



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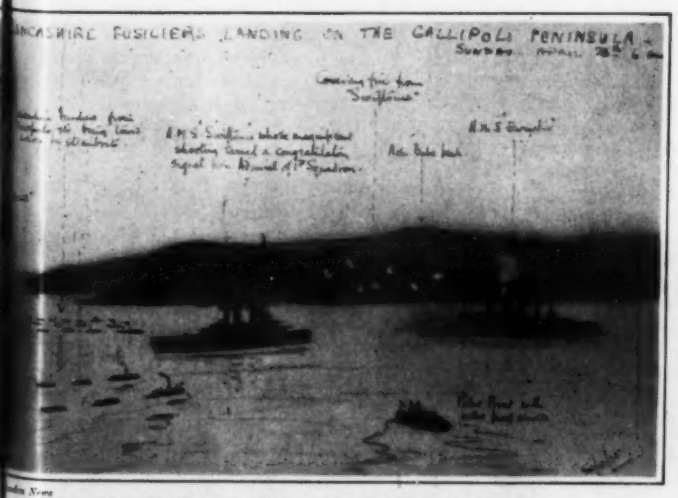
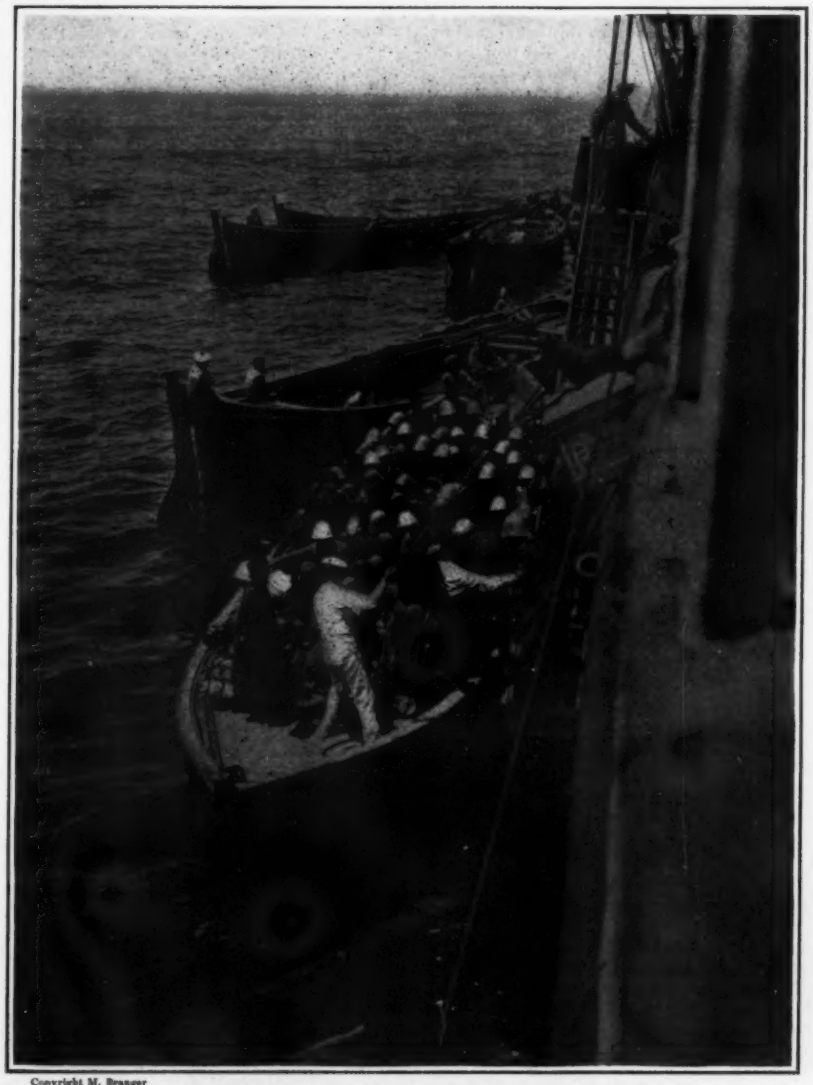
French cruiser "Leon Gambetta."


LANCASHIRE FUSILIERS LANDING ON THE GALLIPOLI PENINSULA
Sunday
covering fire from "Swiftsure"
H.M.S. "Swiftsure" whose magnificent shooling caused a congratulatory signal from Admiral 1st Squadron.
H.M.S. "Dublin"
Achi Baba Heights
Point where the boats touched shore

Illustrated London News

Lancashire Fusiliers landing on the Gallipoli peninsula.



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Colonial infantry on the Dardanelles preparing to land.

THE DARDANELLES

Problems of Geographical Influence*

Physiological and Psychical Influences That Are Affected by Environment

Our individual embodies physiological and psychical activities which are affected by environment. Here the problem is immensely involved, for, as Brinton says, psychical development depends less on natural surroundings than on a plexus of relations of each man with many others.

Natural environment includes first the physical—soil, water, minerals, land form, temperature, moisture in the air, light, electricity, and all operative on an earth in interplanetary relation to the sun. Then is added the animal and plant environment, whose daily pressure on the individual and the group has held in no small way the destinies of civilization. Interwrought with all these natural forces are the human-social factors ever more powerful since the dawn of history. Thus there is a total of infinitely variable factors producing infinitely diverse results upon the body and mind.

The environment of this day and hour is perplexing enough, but environments change: man exchanges one environment for another. The steady drive of our environment in its daily flux is replaced by the shock of a new environment entered in a day or a night or gained by long voyages across the sea. The sum of a man's heredity goes out into his new sphere with him. But how much of this is primal and persistent and how much can be shifted like a garment? The heredity doctors have not answered this question and geographers should have a care. It is a wholesome corrective to remember the number of our possible ancestors. According to Boas,[1] an Eskimo could not have so many as you or I. Royal families share this limitation with the polar man, and one European monarch, it is said, has in the past twelve generations only the meager outfit of 533 ancestors out of a theoretical 4,096. We, however, belonging to a large population of unstable habits might have in twenty generations more than a million each. We are too complex to come to an easy reckoning about ourselves.

By our social memory we carry the old environment into the new, and thus we "compound"[2] environments, and this ends in making environment coextensive with the world. The universality of modern environment for any civilized man appears in our commercial interchange and speaks to us in a war whose center is in Europe, whose circle takes in the world.

Ratzel in showing how Christianity conquered its realm not as direct from Palestine, but as modified on its way through Egypt, Greece and Rome, has given us a good example of such compounding of environments.[3] Geographers have by no means been blind to the difficulty of anthropic problems. Brunhes warns us that truth in geographic relations of man is approximate, and that to claim it as exact is to be unscientific.[4]

"The outstanding psychological fact, then, is the antithesis of a rigid fatalistic determination of human acts by climate and soil."[5]

And he then cites what he calls "antinomies," frontier, urban, racial, and social. Ratzel has a most instructive passage on sources of error due to the neglect of middle members lying between visible workings and their remote causes, the inclination to take a direct line instead of the roundabout way of mediate working causes. This leads either to false results or to the hopelessness of reaching the truth.[6]

Prof. Myres in the closing lines of his little book, "The Dawn of History," admits and emphasizes the vagueness of results in trying to estimate the relations of history, geography, and biology. But his final word is of good cheer:

"If the reader is moved to complain with that other, 'I see men as trees walking,' let him remember that he who said that was well on the way to 'see every man clearly.'"

Thus far our notice of our difficulties has been general. Let us look at the questions of race. "Race is the key to history—what is the key to race?" Thus Griffis inscribes the title page to a volume on Japan. In estimating the force of a given environment on a given time how much shall we allow for race? But we must go back of that. How did environment go into the making of race? But suppose we are not sure what a race is and cannot with any agreement analyze and classify present races! Authorities agree neither upon race, nor upon the efficiency of race in relation to environment. Thus one authority assigns a race cause for the higher status of long heads as compared with broad heads in certain parts of France. The long heads have more wealth and pay more taxes than their brachycephalic countrymen. Is this really a racial result? Or is it due to a fortunate occupation of richer lands, bringing in its train the higher professional and social status and the urban tendencies of the northern blonds? The criteria of necessity and universality need to be pressed home.

The present writer has difficulty, being a layman, in understanding the ethnologists when they classify races. It is increasing to one's comfort, therefore, and saving to self-respect to find a member of the anthropological fraternity saying of the development of races that it is "immensely difficult to separate the effects of various factors," and that "it is not edifying to look at half a dozen books upon the races of mankind, and find half a dozen accounts of their relationships having scarcely a single statement in common. Far better to face the fact that race still baffles us almost completely."[7]

We may add a further observation, that much in this field depends upon paleography, if we are to decipher the origin and migration of races. But here, as Marett says, is a rather kaleidoscopic science, for the continents and bridges which it calls up out of the ocean have a way of crumbling.

Let us illustrate by the so-called Aryan question. It used to be an item in the ethnological creed that most European peoples using languages of cognate features came thither from central Asia by the way of India. But many years ago now it was shown that common language did not prove race kinship. Nor do names of trees and other plants suffice to trace migrations, for men change the names of their trees, and floras migrate in the long marches of time. It has been remarked that if we had no historical knowledge to the contrary, *tobacco* and *potato* might be taken as parts of a European tongue, rather than a loan from the Caribbean natives.

So come the measurer and the calipers in place of the linguist and set up the physical criteria of head form, stature and color, and put in place of a comfortable and discredited generalization the chaos of opinion which is often the precursor to more fixed and defensible conclusions. But such conclusions have not yet been reached. So uncertain is the status of the problem that one writer on the sources of the Germanic invasions says that while some put the origin in Africa, others trace racial differences to environment and others fall into skepticism about the whole matter.[8] This author thinks the Germans are diverse, as a Roman might be anything from York to New Carthage, Corinth or Damascus.

Brinton holds that the origin of this so-called Indo-European group was in the west, the central Celtic tribes moving from the Atlantic region through the Alps to the Danube, a southern series of offshoots peopling the Mediterranean, and the northern, moving southward and eastward from primitive seats on the North and Baltic seas.[9] Another authority thinks with Sergi and Keane that the Mediterranean stock came from Africa and that the dolicho-blond developed after the passage to Europe and the initiation of the Mediterranean water barrier.[10]

Ridgeway,[11] on the other hand, makes two non-Aryan races in Europe, Alpine and Neolithic, overrun by two Aryan races, once thought to have come from Hindu Kush, now believed to have originated in upper central Europe. He argues that to follow Sergi in making the Mediterranean race non-Aryan "leaves out of sight the effects of environment in changing racial types, and that, too, in no long times." He cites the cases of the Boers in Africa and of New World natives changing their latitude. There was gradual change from the short, dark men of southern Europe to the tall blonds of the Baltic. This means more than intercrossing and raises suspicions of constantly working climatic influence. He thinks environment the chief factor in stature and pigmentation. Attention to other animals, in Ridgeway's view, demonstrates this doctrine. He cites the white hares and bears and the tendency of the ptarmigan and the horse to turn white in winter. The horse is cited as shown in varieties from northern Asia to the Cape of Good Hope, and this writer concludes that environment is powerful not only in colorations, but in osteology, and that these changes may be very rapid. The blond Berbers are believed to owe their qualities not to mixing with Vandals and Goths, but to being cradled in a cool mountain region. The fair-haired people have poured for centuries across the Alps and yet hold their own only in the north of Italy. Woodruff does not think they were darkened, but that natural selection eliminated them because they went beyond their latitude range. *Homo Alpinus* is held by different authors as Aryan or as Mongolian from Asia, and as having evolved their brachycephalic character on European soil.

Marett, referring to Ridgeway, thinks he overrates environment, but admits it as premature to affirm or deny that in the *very long run*, round-headedness goes with a mountain life.[12]

To add other items of opinion, confirming the conviction that much fruit has set, but few specimens have ripened, Marett places in north Africa the "original hotbed"[13] of the Mediterranean race, who in Neolithic times colonized the north shore of the Mediterranean and passed by the warm Atlantic as far as Scotland. The same author, keeping close to cover, says that it is now fashionable to place the Teutonic home in northeastern Europe, though he regards it as still something of a mystery. The Scandinavian origin of European peoples is held by some,[14] while J. L. Myres shows the affinity of boreal and Mediterranean man and suggests their Euro-African origin,[15] and Gray's discussion of Myres's paper emphasizes the swift action of environment.[16]

Altogether it is hardly to exaggerate to say that you can find authority for placing the breeding grounds of the European peoples in north Africa, in central Asia, or in any part of Europe, for sending their wandering progeny in any direction of the compass, with any kind of racial mixture or linguistic evolution and with every possible shade of efficiency or inefficiency on the part of environment.

But suppose the Aryan business cleared up, there would remain earlier problems of Paleolithic differentiation and the prolonged twilight journey of man. And suppose we had threaded our way, geological, ethnographical, linguistic, and geographic, down through the differentiations and mixtures and migrations until we have the Teuton and the Celt in north Europe and the British Isles, and our troubles past? Let us see.

You would trace the evolution of the American, as effected by environment. Where will you begin? Not in New England or Virginia. Not altogether in old England. Not altogether in Teutonic Europe. Before we get through with the American we might like to cover all Europe with the network of our inquiry. But we cannot move too broadly; let us turn to the British Isles. There are still the progeny of the pre-Celts of Neolithic age. There came at least three types of Celt, the Gael, the Briton, and the Belge. Roman invasion and rule followed and in due time the Christian religion. Next came the Angles and Saxons and Jutes from across the North Sea, a new deluge of paganism, and a new contribution of racial traits bred in the long past. One would like to know how that old North Sea Teuton differed, fifteen centuries ago, from the Baltic Sea Teuton of the Prussian plain. Was it in the latter's great strain of Slavic blood, or were there other factors. When and where did the present sum of difference between Prussian and Englishman begin to emerge? At any rate, Jutland, Schleswig-Holstein, and the lowlands of the Elbe were poured into our ancestry and were Christianized.

In the eighth century the Viking rovers came across the North Sea, with fresh cargoes of vigor and paganism. The Rhine, Scheldt, Seine and Loire, as well as Britain, felt their power. "From the fury of the Northmen, save us, Lord," runs an old litany. But pirate and robber though he was, here was an element of selection that must not be disregarded. Norway, Sweden, and Denmark, says Greene, "were being brought at this time into more settled order by a series of great sovereigns, and the bolder spirits who would not sub-

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* Abstracts from the address of Prof. Albert P. Brigham, president of the Association of American Geographers, at the eleventh annual meeting at Chicago.

[1] F. Boas, "The Mind of Primitive Man," 84-88.

[2] R. R. Marett, "Anthropology," 122-23.

[3] "Anthropogeographie," I., 175.

[4] J. Brunhes, Inaugural lecture, *Scot. Geog. Mag.*, 29, 362-63.

[5] *Ibid.*, 367.

[6] "Anthropogeographie," I., 54.

[7] R. R. Marett, "Anthropology," 61.

[8] C. Hayes, "Sources of the Germanic Invasions," Studies in Hist. and Pub. Law, xxxiii, 14-15.

[9] D. G. Brinton, "Races and Peoples," 151-52.

[10] "The Mutation Theory and the Blond Race," *Jour. Race Devel.*, iii, 491-95.

[11] William Ridgeway, President's Address, Brit. Assoc. Ad. Sci., Dublin, 1908, 832-47.

[12] Marett, "Anthropology," 107.

[13] *Ibid.*, 104.

[14] Richard, "History of German Civilization," Ch. II.

[15] J. L. Myres, "The Alpine Races in Europe," *Geog. Jour.*, 28, 537.

[16] *Ibid.*, 555-56.

mit to their rule were driven into the seas and embraced a life of piracy and war." But there had been bred into them "in a land that is one third water and one third mountain, where winter lasts six months in the year, endurance, ingenuity, and daring."

In two or three centuries more followed the Norman Conquest, in which the Viking brought to England all that he had taken on and taken in of French life. There follows the further co-ordination of Neolithic, Celtic, Teutonic, and Norse men for five and a half centuries, until the early decades of the seventeenth century and the beginnings of British settlement in America. And this was a selective migration whose story can not be told here, and has never been so fully told as the student of environment might desire. Suffice it to add that no mere paragraph can tell us what kind of people came to Massachusetts or Virginia. Religious, economic and political changes in England, plus the attractions of a fresh world, brought across the sea the elements that have been formative in American life. American environment has not developed all the qualities which we consider as distinctively or typically American.

But in New England, and on the Hudson, the Delaware and the James, new physical and social pressures began to wield their power. After some generations in this environment in the eighteenth century, a new flow began through the passes of the Appalachians. To Timothy Dwight is ascribed the view that thus New England was rid of her restless and insubordinate spirits. Another interpretation is that the best and most progressive men went because they did not like the rule of the Congregational clergy. At any rate, it was another selective migration, by which picked families went into a new environment. Turner is our best authority for what the environment of the middle west made out of the emigrant from the East. It would be easy to show, I think, that in spite of what might seem predominating mixtures of Continental European migration, New England still pervades Wisconsin, that the New England mind was more powerful than the new environment, important as that was, just as the Puritan mind was more powerful than the New England environment.

The selective emigration moved on by prairie schooner and transcontinental railway to the Rocky Mountains, the intermont plateaus, and the Pacific Coast. Here are mountains, deserts, mines, giant forests, irrigation, and a new ocean. Whence came the Californian? From New England, Ohio, Iowa, Kansas, Colorado. Is that all? Every one of the following regions is there, with 5,000 to 200,000 representatives. Germany, Ireland, England, Canada, Italy, Mexico, Russia, Scotland, Sweden, Switzerland, Portugal, Norway, France, Denmark, Austria, Wales, Turkey, Spain, Greece, China, islands of the Atlantic, Australia. The German, Canadian, Englishman, Spaniard, and Russian that wanted to be or do something new are there. And it is a compelling environment, of sky and mountain, ocean and plain, forest and desert, mine and field. Prof. Royce, a native Californian, thinks the typical character there is a combination of strength and weakness, with wandering in the blood, lack of social responsibility, recognition of no barriers, desire for sudden wealth, love of difficulty, unaccented love of home, with more love of fullness of life than reverence for the relations of life."[17]

One more picture of this western life must here suffice—it is by a journalist—of the American of the far northwest, where New England and the "Mayflower" appear not, whose men followed the Missouri from Kentucky, Indiana, Missouri and Arkansas, tall, big-boned, and stalwart, self-assertive, nervous, quick in action, acting before they think and thinking mainly of themselves, their European origin so far behind them that they know nothing of it. Their grandfathers had forgotten it. In a word, they are distinctly, decidedly, pugnaciously and absolutely American."[18] Making what allowance you will for Ralph's exuberant rhetoric, and Royce's habit of philosophizing, better to be solved in the twenty-first century than to-day is the problem of the function of environment in shaping American life. As we have seen in this sketch, the geographer will not work alone, the historian, sociologist and philosopher will take a hand.

[17] J. Royce, "California," Am. Com. Series, 499-500.

[18] J. Ralph, "Our Great West," 141-42, quoted in abstract.

Italy and Engineering

In whatever direction we turn in the engineering field we find Italian inventiveness and craftsmanship occupying a high place.

The fame of Italian internal combustion engineering is world-wide, and in the matter of the electrification of railways the record of Italy stands so high that no new schemes are undertaken anywhere without a careful consideration of the splendid work done beyond the Alps.

The construction of electrical machinery of all kinds seems to come with special facility to Italian mechanics, and in this connection it is, of course, recalled that the most delicate electrical machinery in the world, that of practical wireless telegraphy, was the result of the genius of Italy's most famous engineer, Guglielmo Marconi, who carried out his first experiments in connection with his system of wireless telegraphy at Bologna.

In the realm of marine engineering Italy is in the very front rank, as is shown by the design and equipment—with ten 14-inch guns and oil-burning engines of 50,000 horse-power—of her latest super-Dreadnought, the £3,500,000 Dandolo. And Italian submarines are said to be even more formidable than those of Germany.

In the peaceful domain of civil engineering Italy has much to show the world with pride, as was indicated recently by Professor Luigi Luiggi, D.Sc., M.Inst.C.E., the renowned president of the Italian Society of Engineers.

The economical utilization of her water supplies has made Italy an example to those lands where water is scarce, especially as regards the help given by the State to many great schemes of irrigation.

Without irrigation, the marvelous orange groves, the bountiful orchards and vegetable gardens, which give such valuable products for exportation to Central Europe and North America, would offer but a scanty return to their owners; but especially the luxurious and extensive meadows of the valley of the Po—which are intensely green all the year round, and give even seven or eight crops of fodder per year—could not exist, and barely one or two cuttings of grass could be raised, because the land during the five or seven months of the hot season remains generally without a drop of rain from the sky, and the vegetation is exposed to a pitiless sun; while during the winter months many regions of Italy would be flooded by the torrential rains.

By the work of the hydraulic engineer and the intelligence and perseverance of the agriculturist, in regulating the natural water-courses, impounding the water in reservoirs, or raising it from the subsoil, or from the natural streams, and then distributing this water intelligently over the land at the proper time—that is, by scientific irrigation—the waste sandy plains of Lombardy have been transformed into the most fertile meadows of Europe, and the orange-groves around the coasts are so plentiful and beautiful as to induce Goethe to give to Italy the name of "the land where the orange blooms."

There are already many large reservoirs, especially in Northern Italy, such as the Lagastrello, Brasimore, Gorzente, Devero, Adamello, and others, but the largest of all is now in construction in Sardinia, across the River Tirso. The dam of masonry is 55 meters high (179 feet), and is of gravity section. It will impound 350,000,000 cubic meters (12,250,000,000 cubic feet) of water, sufficient to irrigate from 20,000 to 30,000 hectares (about 50,000 to 80,000 acres) of land capable of being cultivated for early vegetables, fruit, oranges, olives, vines, and such good-priced products.

Several other dams are to be built soon in Southern Italy, the most important being on the rivers Bradano, Sila, Simets, and Fortore. The last will be 75-meters high (243 feet), and will impound 410,000,000 cubic meters (14,350,000,000 cubic feet) of water and irrigate about 100,000 acres.

The water from all these artificial lakes is generally used first for motive power—in some hydroelectric installations, which in northern Italy are very plentiful, and this helps in lowering the price of the irrigating water. Afterward it is distributed by means of canals to the different farms.

The engineering works consist of a submersible dam of very substantial masonry, built across the river, and capable of raising the level of the water to that of the country to be irrigated; of some controlling sluices at the canal head, and of a main canal, with lateral distributing ditches, provided at their intake with some apparatus for measuring the water to be delivered. Generally, the "Gipelett Weir," or some such over-fall weir, is used. No mechanical meters are adopted, except for very small deliveries.

Of the canals of modern times, the most interesting, in their engineering features, are the Villoresi, with 44 cubic meters, the Marzano with 30 cubic meters, the Veronese with 15 cubic meters, the Zegliamento with 17.5 cubic meters per inch. They are really models, both from the engineering point of view and the perfection of their administration; so much so, that many engineers come from all parts of the world to study them. The largest and longest of all is the Cavour canal, with a length of fully 100 miles. It was built in 1855-65 by a private company that failed, and was bought over by the State.

This canal, the most important in Europe, was the means of transforming an almost barren region of 250,000 acres of sand and gravel—useful only for growing timber and bushes—into the most fertile rice fields and meadow land of Italy, where the best Parmesan and Gorgonzola cheeses are produced. A still larger canal is about to be started, the Emiliano canal, with a greatly increased capacity and a length of 120 miles. It is estimated to cost £12,000,000.

The State considers it as its duty to help all these undertakings. Irrigation puts under cultivation large tracts of land of very little value, and almost sterile, and part of the population can thus find useful employment in the cultivation of this land, otherwise nearly useless.

Italy has an increase of population of almost 1,000,000 souls per year, and some 500,000 to 600,000 people are obliged to emigrate, especially to North America, or Central Europe, while some 100,000 go to Argentina, and 50,000 to other countries round the Mediterranean.

To moderate this exodus, which is not beneficial to the country, the State encourages irrigation by granting a subsidy of 3 per cent. per year for a period of ten years on the capital spent in the construction of the main canal and its principal branches, 2 per cent. per year for the following ten years, and 1 per cent. for another period of ten years. Then the subsidy ceases. But if the canal is arranged in such a way as to help to control the flood water of rivers—as when an impounding reservoir is also built—then some subsidy is also granted on the capital in the proportion of 20 per cent. to 50 per cent. of the expenditure. For instance, for the Tirso reservoir and canal, estimated at about 30,000,000 francs ($6,000,000), the State pays 3,000,000 francs for the beneficial effect on the state of the river, and grants a yearly subsidy of 150,000 francs ($30,000) for fifty years for the canal. After ninety-nine years all the works become the property of the State.

The conclusion is that irrigation is very beneficial to the individual farmer when he can get the water by paying 30 francs to 50 francs per hectare per year ($2.67 to $4.15 per acre), but not to the administration of the canal during at least the first thirty years; so the undertaking requires a great help from the State during this trying period. But in the meantime the State, in the form of taxation, and in the increased welfare of its citizens, reaps a large benefit from these works, which is more than sufficient to repay amply all the sacrifices made for this purpose. Without irrigation Italy would not be able to feed two-thirds of its present population; as it is, with its wonderful network of irrigating canals, it has become the "garden of Europe," and is now preparing to extend irrigation in order to be able in thirty years' time to feed a population of 50,000,000 to 60,000,000 inhabitants. These are the miracles accomplished by scientific irrigation, and this explains also the reason why the Italian State encourages and helps financially all such undertakings. —*The London Daily Telegraph.*

Sugar Beet Cultivation in England

With the cutting off of the sugar beet exports to this country from Germany and Austria, there is little need to emphasize the importance which the question of obtaining alternative supplies is likely to assume before long. Experts, indeed, says *The London Daily Telegraph*, calculate that, despite the government's recent huge purchase of sugar, a famine in this particular article of food is inevitable before the summer. Roughly speaking, 90 per cent of British sugar beet comes from the Continent.

In 1913-14 Germany and Austria produced over 6,000,000 tons of beet sugar, of which 2,000,000 tons were exported to England. Statistics show that in the same period over 8,160,000 tons of sugar beet were produced on the Continent, and its cultivation has brought agricultural prosperity to many hundreds of farmers.

With the object of drawing the attention of farmers to the importance of the subject, the South-Western Railway Company, in conjunction with Messrs. Kelly's, are at present organizing a series of meetings in the agricultural towns served by the line. After thorough investigations of the soil between Padstow and London, under expert guidance, it has been proved that Surrey, Hants, Wilts, Dorset, Somerset, Devon, and Cornwall are eminently suitable for the cultivation of beets.

To produce the sugar needed in England, viz., 1,322,000 tons of beet sugar and 576,000 tons of cane, it would be necessary to produce some eight to nine million tons of beet, or, roughly, to put 680,000 acres under cultivation. The British trade at present is worth about £20,000,000 a year to Germany and Austria. There is no reason why a large proportion of this should not go into the British farmers' pockets, and the success of the sugar beet industry in England should be the more assured from the fact that it is calculated, even under peace conditions, there will be no beets exported from the Continent in ten years' time, because there will be no land available for its cultivation. Meanwhile the consumption of sugar in every country is increasing enormously.

Machining Shrapnel Shells*

Many Accurate Operations Necessary to Produce a Perfect Projectile

By Douglas T. Hamilton

SHRAPNEL shells are manufactured either from bar stock or forgings. The bar stock method, however, is not considered as satisfactory as forging because of piping, so that the greater number of shrapnel shells made at the present time are turned out from forgings. The first step, therefore, in the making of a shrapnel is to cut off a billet of the required length from a bar of steel of the necessary constituents. In the making of an 18-pound shrapnel shell, the billet is cut off from a bar of 46-point carbon, 70-point manganese steel in machines of different types. One way of doing this, as

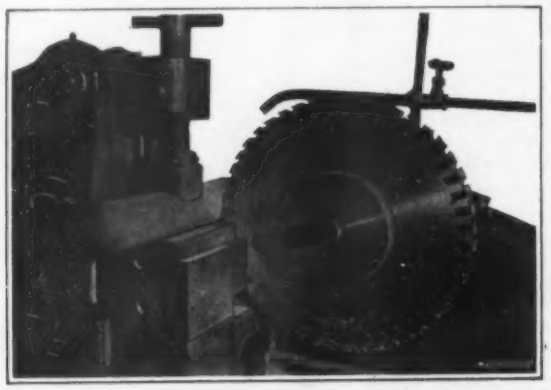

Fig. 1.—Cutting billets from steel bars to make shrapnel shells.

shown in Fig. 1, is to use a cutting-off machine having an air clamp for holding the bar in place while it is being cut off. A duplex saw, as shown in the illustration, provided with high-speed steel inserted teeth, performs the cutting operation. The billet for an 18-pound shrapnel is 3½ inches diameter by 4½ inches long. It is then forged to shape, as has been previously explained.

Assuming now that the forging has been completed, the following is a summary of the machining operations on the shell up to the point of assembling. In one plant where this work is being done, the shrapnel shells are put through in lots of 120, forty to a box. Out of every 120, one shell after heat-treatment, is tested for tensile strength. The tensile strength before heat-treatment must be 30,000 to 40,000 pounds per square inch, and 80,000 to 90,000 pounds per square inch after heat-treatment.

The first machining operation on the forged shell is to cut off the ragged end, which is generally from ½ to 1½ inch longer than that required for the finished shell.

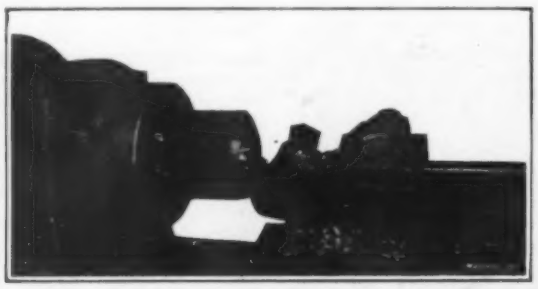

Fig. 2.—Facing off the end of a shell forging.

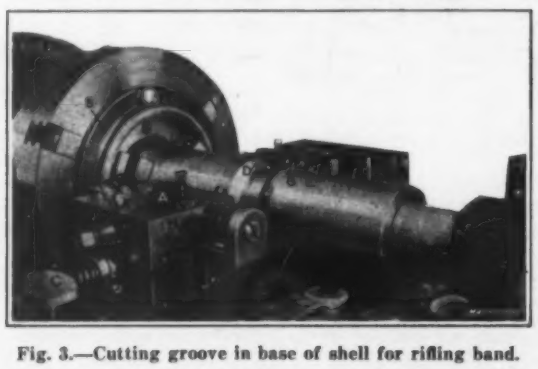

Fig. 3.—Cutting groove in base of shell for rifling band.

The next roughing operation is to face off the bottom or closed end of the forging, bringing the shell to approximately the correct length. There are also many ways of performing this operation. One method is to grip the forging in a chuck, as shown in Fig. 2, in an ordinary lathe and face off the end with a high-speed steel tool. From ¼ to ⅜ inch is faced off the end.

Practically every type of engine lathe and turret lathe as well as special machines are used for turning and boring shrapnel forgings. A summary of the methods of machining employed in a large Canadian plant turning out shrapnel will be described. In this plant, the first rough-turning operation is handled on a flat turret lathe. For this purpose, the shell forging is held on an expanding arbor and is driven by a dog fastened to it and driven by the faceplate of the lathe. A multiple tool turner is first brought into position and takes a cut of about ⅛ inch from the diameter for practically the entire length of the shell. The next tool then faces off the end of the shell to length.

The shell forging is now ready for cutting the rifling band groove and producing the waves. This is handled in an ordinary engine lathe equipped with a special fixture, carrying grooving, waving and under-cutting tools. Fig. 3.

The third machining operation is accomplished in a flat turret lathe, and consists in facing the open end of the shell, boring the powder pocket and facing and boring the diaphragm seat, and also turning the angular surface on the external nose of the shell. First, a roughing drill is brought in to rough out the powder pocket. The turret is then indexed and a tool for turning the angle of the nose is brought into position. The machining on the nose is then accomplished by operating the cross-sliding head. Then a roughing cutter is brought in to rough-bore the powder pocket. The turret is again indexed and a finishing tool is brought in to finish the powder pocket and face the diaphragm seat. This finishes the machining operations on the shell previous to heat-treatment.

As was previously stated, the tensile strength of a forged shrapnel shell after heat-treatment must be 80,000 to 90,000 pounds per square inch, and in order to obtain the desired physical qualities, it is necessary that the heating operations be properly conducted. Several methods of heat-treating employing different cooling solutions are used in the manufacturing plants making shrapnel shells. One method, as shown in Fig. 4, is to heat the shell in an electric furnace that contains a barium-chloride bath, heated to a temperature of about 1480 degrees F. The shells are left in this furnace for a half hour and are taken out and dipped in a bath of cotton-seed oil heated to a temperature of 113 degrees F. The temperature to which the shell is heated varies with the different constituents of the steel and practically every different batch of 120 shells requires a slightly different temperature. The proper temperature is determined by cutting out a section of a heat-treated shell and testing it for tensile strength. The next step is to draw the temper on the open end of the shell for about three-quarters of its length. In this operation an oil bath, heated by a muffle gas furnace to a temperature of about 1000 degrees F., is used. The shell is allowed to remain in the bath until it reaches the heat of the bath.

Fig. 4.—Heat treating shrapnel shell in barium chloride bath.

One shell from a batch of 120 is now cut open in the proximity of the powder pocket and the cut-out section sent to the government inspectors to test it for tensile strength. Each one of the shells in the batch, in addition, is tested for hardness by a scleroscope as shown in Fig. 5. Before testing for hardness, the shell near the band groove is polished so as to get a true reading, then placed in a fixture, and the hammer of the scleroscope allowed to drop on it. The reading should be between 40 and 50, indicating an elastic limit of 80,000 to 90,000 pounds per square inch. The shell must not be ruptured at the point tested when the charge in it is exploded or when the charge in the case is set off. Should the shell upset near the rifling band groove when it is being propelled out of the gun, it would tear out the rifling in the bore of the gun.

Experience with the scleroscope has disclosed the existence of a definite relation between the hardness and strength of metal. In determining the strength of metal, two stages are recognized: First, the elastic limit, yield point or load required to start permanent set; second, the ultimate strength or load required to terminate permanent elongation and reduction of area in rupture. The hardness indicated by the scleroscope is intimately related to the elastic limit. The elastic limit increases more rapidly than the hardness from 43 to 45, this being the minimum index of the strength value required. As an elongation of 8 per cent in 2 inches is also called for, there must necessarily be an upper limit to the hardness. On the steel used for shrapnel which is generally about 50-point carbon, 70-point manganese, the maximum hardness should not

* Courtesy of *Machinery*.

be over 60 as indicated on the scleroscope scale.

On some makes of shells, particularly the British, the nose is closed in before performing the third series of machining operations. The closing in is generally accomplished in a hydraulic or power press. Before closing the open end of the shell, it is heated in the lead bath, which is kept at a temperature between 1450 and 1500 degrees F. The steel diaphragm, which is larger in diameter than the nose of the shell, is first thrown in. Then the shell is placed in the press, and a cone-shaped die descends, closing in the nose to the proper shape and diameter. The third machining operation consists in finishing the radius on the nose, both inside and outside, and cutting the thread. This is done in an ordinary engine lathe with a turret on the saddle. The boring is done with cutters held in boring-bars and the thread cut with a Geometric collapsing tap. The thread on the 18-pounder is 2.94 inches diameter, 14-pitch, Whitworth type.

The exterior surface of a shrapnel shell is straight for a portion of the length and then curved on the nose. While the limits required are not extremely close, it is necessary where large production is required, to accomplish the finishing operations on the exterior of the shell in some way by which fairly close dimensions can be secured as well as large production. Grinding has therefore been recommended for finishing the exterior of the shell. One method of grinding shrapnel shells in which a wide faced wheel is used that covers the entire ground surface, is shown in Fig. 6. This machine carries a wheel about 8¼ inches wide, 20 inches diameter. The grinding wheel is rotated at 1200 R. P. M., and the work at 50 R. P. M. The depth of cut is about 1/32 inch, and the time to complete one shell varies between two and three minutes. For grinding, a plug is screwed into the open end of the shell. This is held on the tailstock centre and a chuck holds and drives the shell from the other end.

In order to rotate the shrapnel when propelling it out of the howitzer, it is necessary to put on a rifling band to take the rifling grooves of the gun bore. As a rule, these rifling bands are made from copper tubing and are simply cut off in a hand screw machine or turret lathe. The next operation is to close in the rifling band on the shrapnel shell. The ring is dropped over the shell and a fixture is used to locate it in the correct relation to the groove in the circumference of the shell. Then a slight pressure is exerted on it to align it properly in the groove. It is now placed in the banding machine. This particular machine is provided with six dies as shown in Fig. 7, and back of each one is a hydraulic cylinder operated by water pressure. Two squeezes are necessary to close the rifling band properly into the groove, the shell being given a half turn after each squeeze.

There are several different machines on the market for performing this closing in operation on the rifling band.

In one method of machining the rifling band to the correct shape a lathe is used which is provided with a chuck for holding the shell and which carries in the turret a revolving centre for additionally supporting it. The machining is done by form tools which are of the correct shape. Before any other machining operations can be accomplished it is necessary to put in the tin powder cup, brass fuse tube, bullets and resin. The tin powder cup is slipped in past the steel diaphragm, then both parts are allowed to drop to the bottom and the fuse tube is screwed into the diaphragm. The required number of lead bullets, which for the British 18-pound shrapnel is about 375 per shell, is then poured in. The bullets are held in a tank and are allowed to flow out upon the opening of a stop-cock. In order to pack the bullets solidly, a compressed air ramming device forms the base upon which the shell rests while the bullets are being poured in. This is operated three or four times for the filling of each shell and arranges the bullets compactly.

The resin is now poured in, as shown in the center of Fig. 8. This is carried in the tank which is heated by a gas furnace and is poured in almost level with the top of the bullets. The shell is then placed on the scale in the immediate foreground and weighed. One dram plus or minus is allowed as a variation, and in order to secure this, more or less resin is poured in until the correct weight is obtained. The brass fuse socket is now screwed in as shown to the left of the illustration, and upon the completion of this operation the shell is ready for the fourth and last machining operation. This last operation consists in machining the brass socket on the outside diameter to conform to the radius on the nose of the shell and boring on the inside and threading to fit the fuse body. Upon the completion of the machining operations, the plug is screwed in, the shell stamped, cleaned, weighed and inspected by government inspectors. After this, the shell is given two coats of paint and a red band is painted around the nose. It is now packed in boxes holding six shells and is ready for shipment. This completes the manufacture of the shrapnel shell.

Fig. 5.—Testing hardness of shell with scleroscope.

Fig. 6.—Grinding shells accurately to size.

Fig. 7.—Machine for pressing rifling bands into shells.

Fig. 8.—Filling the shells with bullets and resin.

Labor Statistics of Coal Mining

THE coal mines of the United States gave employment in 1913 to nearly 750,000 men (747,644), of whom 571,899, or 76.5 per cent, were employed in the bituminous mines and 175,745, or 23.5 per cent, in the anthracite mines of Pennsylvania. The average working time (257 days) made by the anthracite workers and by the whole number of employees (238 days) in 1913 was the largest on record, and the average time made by the bituminous mine workers (232 days) was exceeded in three years only since 1890, namely, in 1899, 1900, and 1907. The bituminous mine workers also established a new record for the average production per man for one year, 837 tons, and the average tonnage per man in the anthracite region, 520 tons, in 1913 was larger than in any preceding year with the exception of 1911. The average tonnage per man per day in the anthracite mines has shown a declining tendency since 1899 and has decreased each year since 1908, this average in 1913 (2.02 tons) being the lowest made since 1892. The average production per man per day in the bituminous fields, on the other hand, has shown an increasing tendency during the twenty-three years that these statistics have been compiled, though in 1913 there was a slight change in the other direction from 3.68 tons per man in 1912 to 3.61 tons in 1913. The apparent increase in the efficiency of the employees in the bituminous mines has been due, as shown elsewhere in this report, to the steady increase in the use of mining machines and to the increased ratio that machine-mined coal bears to the total bituminous production.—*Mineral Resources of the United States, 1913, Department of the Interior.*

The Manufacture of Condensed Milk, Casein, Etc.—I*

Discussion of Methods of Analyses

By R. T. Mohan, B.A.Sc.

As early as 1810 an English Patent was granted to De Heine covering the evaporation of part of the water from milk, and its preservation with cane sugar. Other early English Patents on condensed milk were granted to Newton in 1835, Grimway in 1847, De Lignac in 1847, and in France to Appert in 1827. The first patent for a vacuum pan for evaporating milk was granted, I believe, to Green in England in 1813 (English Patent 3,754).

The object of these early inventors is clearly shown in Newton's English patent No. 6,787, 1835, which reads: "For preparing animal milk so that it may be preserved for any length of time with its nutritive properties, and capable of being transported into any climate for domestic and medicinal purposes, this being effected by adding to the milk a certain amount of sugar and evaporating it by any suitable means, using only a gentle heat to quicken the operation. It may be brought to the consistency of cream, honey, or soft paste, or even into dry cakes. Cocoa, coffee, or tea may be evaporated with it."

The first instance of the successful manufacture of condensed milk on a commercial scale in America was in 1856 by Gail Borden, founder of the present firm of Bordens (U. S. Patent 15,553 in 1856; English Patent 509, 1856). Up to the year 1861 there was little demand for condensed milk, but during the civil war a great demand was created, and from that time on it has steadily increased.

The Anglo-Swiss Condensed Milk Company was started by U. S. Consul Page, of Zürich, Switzerald, who first made the product in 1865, and in 1866 incorporated the Anglo-Swiss Company, which now produces over 80 per cent of all the condensed milk manufactured in Australia and Europe.

Milk was first preserved by sterilization in 1856, and unsweetened concentrated milk, or what is now known as evaporated milk, was first successfully manufactured in Highland, Ill., in 1885.

The U. S. Census Report of 1909 shows a production of 214,518,310 pounds of sweetened condensed milk and 280,278,234 pounds of unsweetened evaporated milk, increases of 8 per cent and 154 per cent, respectively, over 1905. The 1913 output in the United States amounted, I am told, to about 250,000,000 cans of sweetened and about 350,000,000 pounds evaporated.

The *milk supply* for the condensing must be ample for the factory's capacity, and must be of the highest quality. It is under the rigid inspection of the factory, and constant inspection is also conducted of the herds, pastures, barns, and dairies. Rigid instructions are enforced in regard to cleanliness of the animals and dairies. No feeding or other operation which would raise dust is allowed for one hour previous to milking. Strict instructions are issued against the use of certain foods, such as turnips, garlic, etc., and only limited amounts of ensilage are allowed. Immediately after milking the milk is cooled and aerated by running it over block tin coils through which cold brine or water circulates, and then stored in a cool place till brought to the factory. Each can as delivered at the factory is opened by the receiver, who is able to detect any undesirable odor in the milk. In addition to the flavor, the temperature is noted. Tests are also made for acidity, any milk above 0.2 per cent being usually refused. As the farmer is usually paid on the basis of percentage of fat, a small sample is taken each day and tested for fat, or sometimes the test is made on a composite sample of a week's delivery, the sample being preserved with mercuric chloride.

It is customary to make frequent bacteriological tests on the supply from each farmer. A good practical test for the number of organisms present in the milk is the reductase test, which is based on the fact that normal cow's milk has the power of decolorizing certain dyestuffs, the time of decolorization (reduction) depending on the number of micro-organisms it contains. The test is conducted as follows: 1 cubic centimeter of methylene blue solution is mixed in a glass tube with 10 cubic centimeters of the milk to be examined, 2 cubic centimeters of paraffin oil is floated over it to exclude air, and the tube is kept at about 115 deg. Fahr. (46 deg. Cent.). If the dye is decolorized within one hour, the milk is regarded as very bad from a hygienic standpoint; if decolorized within three hours it is of second quality; if the color persists for more than three hours the milk is good.

Another test depends on the decomposition of hydrogen peroxide by an enzyme present in milk, known as catalase, the catalytic power of which is increased by the bacteria present. This method has not come into general use in Canada.

To determine the nature of the bacteria, so-called "fermentation tests" are applied. The best known of these is the "Wisconsin curd test," in which a pint of milk is heated in a sterilized jar to about 98 deg. Fahr., 10 drops of standard rennet extract is added, and the jar is closed and incubated for about eight hours at 98 deg. to 102 deg. Fahr. The jar is then opened and the odor observed, the curds are cut with a knife, and the appearance is noted. Good clean milk contains practically no organisms but the lactic acid bacteria, which produce no gas and no bad odors, and the curd formed, therefore, should have only an occasional irregular hole. Milk produced under insanitary conditions will produce more or less gas, and the curds will be full of large irregular holes.

Another "fermentation test" is conducted by incubating samples of the milk in sterilized tubes at about 100 deg. Fahr. After twelve hours the samples are examined, and the bacterial content of the milk is judged by the character of the curd, etc.

The milk after weighing is poured through a large strainer and run into large enameled vats, fitted with stirrers, on the floor below. The room in which these vats are placed is kept as cool as possible. The treatment of the milk from now on depends on the product to be made.

Condensed Milk.—The Canadian standard is not less than 28 per cent of milk solids and not less than 7.7 per cent of milk fat. The last inspection of milk made by the authorities and recorded in Bulletin 257, Inland Revenue Department, shows that the product on the market complies exceptionally well with this standard.

The fresh milk is drawn from the receiving vats into large copper vats known as fore-warmers, where it is heated after addition of the requisite amount of cane sugar. Some of the fore-warmers are heated by copper jackets, while others depend on live steam from an open pipe; the latter method introduces some condensed water from the steam, but the amount is very small. The amount of sugar added varies from 16 to 19 pounds to 100 pounds of raw milk. In some cases the sugar is added to the whole quantity of milk before it goes into the pan, while in others one half or three quarters of the milk is run in, and the sugar added to the remainder. The temperature to which the milk is heated before it goes to the pan also varies in different factories. These variations by different operators are mainly directed toward overcoming crystallization in the finished product.

The milk is now sucked into the vacuum pan and the "condensing" operation begins. The concentration is carried out at a vacuum of about 28 inches and a temperature about 140 deg. Fahr. The vacuum pans used are single type evaporators made of copper, round at each end, with straight sides. They are heated by a steam jacket at the bottom and also internally by large coils, and are connected to a water-jacketed condenser.

The "condensing" takes about two hours. Samples are drawn off at frequent intervals through a double sealed test cup. The consistency is tested by means of hydrometers, the end point being 35 deg. to 36 deg. Baumé. More often, however, the sample is cooled to 70 deg. Fahr., and the appearance and the way the milk "strings" are noted. The operators get quite expert in judging the concentration of condensed milk in this way. As soon as the right consistency is attained, the valves are opened, and the finished product is run into ordinary milk cans (about 14 gallons), which are then placed in a shallow iron tank through which cold water circulates; here they are stirred and cooled, to make the product smooth and free from lumps. The tanks are provided with a series of can wheels, driven from a central shaft, and so constructed that the milk cans fit rigidly on them. A stationary wooden paddle is placed in each can, and as the cans revolve the milk is stirred and cooled. After cooling, the syrupy product is filled into cans and sealed. This product is not sterilized, preservation being dependent on the low percentage of moisture present and the absence of air in the cans. Table 1 shows the average composition of the product compared with that of other evaporated milks and milk powders. If properly made and kept air-tight, it keeps for several years. It contains too much sugar for use as an infant food.

Table 1.

Average composition of condensed milks.

	Solids. %	Ash. %	Fat. %	Protein. %	Lactose. %	Cane sugar. %
Condensed whole milk	72·6	1·6	10·0	8·0	12·0	41·0
Condensed skim milk	70·0	2·0	1·0	10·5	14·5	42·0
Evaporated milk	26·3	1·6	7·9	7·7	9·1	—
Whole milk powder	96·3	5·6	26·8	32·0	31·9	—
Skim milk powder	91·7	6·9	1·7	33·8	49·3	—

The product obtained as outlined is made from whole milk and complies with the standard in every way. A skim milk product is also made, but this is always sold as "skim condensed milk." It is manufactured in the same way. (See Table 1 for composition.)

The great difficulty in the manufacture of condensed milk is to prevent "sandiness," due to crystallization of the lactose or cane sugar. A decrease in concentration to prevent this is impossible, as the successful keeping of the product depends on its having less than 30 per cent of moisture, and to effect this the sugar must be added in a proportion to give about 41 per cent cane sugar. Over-concentration and the use of too much sugar increases this sandy condition, but even with proper conditions of amount of sugar and percentage of solids, the lactose generally crystallizes. Each manufacturer seems to have his own method of overcoming this, and for this reason practice varies in regard to the method of and time of adding sugar, temperature, etc., in the pan, and the method of cooling.

On opening a can of condensed milk a layer of sugar is often found on the bottom. This may either be lactose which has settled, or cane sugar separated out owing to an excess being used. It is not detrimental to the product, except that the layer of milk above may not have enough solids to preserve it as long as it should be kept.

Another defect in condensed milk is so-called "buttons." On opening a can and pouring out the contents, one or more small lumps, varying in size from a pinhead to a bean, may be found, attached to the side of the can. These are called "buttons," and are not easy to explain. Some state that they are insoluble casein compounds formed by the action of the metals of the tin plate. The peculiar feature, however, is that they appear to grow. A satisfactory explanation for this trouble is yet to be given, I believe.

Occasionally a can of milk is found to be in a thick, gelatinous condition. This denotes too much milk solids and not enough cane sugar to make a syrup.

Other defects are rancidity, brown color, blown tins, or putrid odor. These conditions are due to too low percentage of solids to prevent bacterial changes, but at most they are rarely very marked until the milk is from two to four years old.

Thus, it is seen that the manufacturer is faced with a difficulty as regards this product. Too little sugar may result in a gelatinous product or one that will not keep, while too much may cause excessive "sandiness" and separation.

Evaporated milk in Canada is defined as milk from which a considerable portion of water has been evaporated, and contains not less than 26 per cent of milk solids and not less than 7.2 per cent of milk fat. This product, therefore, does not contain any added sugar, and is preserved by sterilization.

The milk is drawn from the receiving tanks into the fore-warmers as before. Here it is brought to a boil, and then drawn into the pan and condensed as before, the operator drawing off an occasional sample and testing the solids by hydrometer; when the proper density is reached the valves are opened, and the milk is run over a series of cooling coils to prevent any rapid multiplication of organisms. From the coolers the milk runs into large copper vats, and a sample is tested for fat and solids. If these tests are satisfactory, the milk is next homogenized by breaking up the fat globules into very minute particles and mixing them so intimately with the caseous matter of the milk that the cream does not rise to the top. It is claimed that homogenizing makes the milk more digestible. This process is accomplished by heating the milk to about 185 deg. Fahr. and forcing it through fine metal capillary tubes under a pressure of about 250 atmospheres against a conical surface of agate or metal. Homogenized milk cannot be separated by means of a separator. From the homogenizer the milk goes to the filling machines, where it is run into cans, which are

* Paper read at the Toronto meeting, 1914, and published in the *Journal* of the Society of Chemical Industry.

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sealed and transferred to the sterilizer. The sterilizers are large circular iron drums, with a revolving framework inside. The cans, in crates, are placed in compartments of the revolving framework. When filled, the door is closed, the retort nearly filled with water, and the temperature raised to the desired point and maintained for the necessary time, the can revolving all the time. The steam is then turned off and cold water run in till the cans are cold. The time and temperature are very important and are very variable, so that this part of the work is in charge of experts. The factors governing the sterilization are acidity, solids, fat content, the season of the year, and size of cans. Milk of high acidity (over 0.4 per cent) will easily curdle with high temperature, hence the reason for keeping the acidity as low as possible on the fresh supply. The effect of acidity on the milk is shown by Table 2, made from actual experiment. The same milk was used in each instance and the same temperature and time.

TABLE 2.

Effect of increased acidity on milk. Fresh milk 0·17% lactic acid.

Concentration.	Acidity.	Condition of milk.
1·58 : 1	0·30	Not precipitated
1·74 : 1	0·34	" "
1·90 : 1	0·40	" "
1·99 : 1	0·43	" "
2·11 : 1	0·48	Small lumps of curd
2·25 : 1	0·54	Large " "

NOTE.—Chemical changes during concentration and sterilization apparently affect the acidity.

Milk of different seasons will stand different temperatures, fortunately the highest in the summer. The fresh milk varies in composition with the seasons, and hence the concentration also has to be varied to bring the product up to standard. Table 3 illustrates this:

TABLE 3.

Variation in concentration with seasons.

	Solids in fresh milk.	Concentration.	Solids in condensed milk.	Condition of condensed milk.
June	12·68	2·00 : 1	25·38	Smooth, no separation or curdiness.
August	11·75	2·21 : 1	26·01	
November	13·40	1·99 : 1	26·62	

NOTE.—Lower concentration causes separation of fat, and higher causes curdy milk.

(To be concluded.)

Principles of Coal Sampling*

WITHOUT question the principle point in the entire range of coal inspection and analysis is in the sampling. If the sample taken is truly representative of the entire lot, the results, if accurate in themselves, furnish correct information as to the larger mass of which the sample is a part. If, on the other hand, the sample is in error, the results of the analysis though correct in themselves will be in error so far as they relate to the mass under consideration. Throughout the process of sampling two points must be observed with scrupulous care:

First—The sample taken must be representative of the whole, that is, the distribution of the various substances which go to make up the original mass must be maintained without any change in the relative amount of the various constituents.

Second—The moisture content, which changes readily, must be under exact control so that at any stage the ratio of moisture present to the original moisture of the mass may be definitely known.

As stated above, the first essential in a sample is that it shall truly represent the mass of which it is a part. To secure this result a few fundamental conditions must be observed, as follows:

The gross sample must be representative of the various kinds of material present. That is to say, a mass of coal consists of fine stuff, lump, bone, slate, pyrites, and other constituents. As a rule the "fines" differ in composition from the lump, hence the sample must have these two sorts of material in their proper proportion. The same is even more true of slate or pyrites, of which the composition differs so widely from that of the major part of the mass. An undue amount of such material would cause a serious disturbance in the accuracy of the sample.

In procuring a representative sample a large element of safety resides in the quantity taken. In general, the larger the amount, the more representative it will be. However, conditions differ. It is easier, for example, to procure an even sample from the face of a working vein or from a carload of screenings than from a carload or other mass or lump of run-of-mine coal. In the latter cases larger amounts should be taken than in the former.

The limits of practicability for the proper handling of the sample must, however, be considered. In general, the gross sample should weigh approximately from 200 to 600 pounds. Doubtless 200 pounds of screenings, taken with fairly good distribution throughout the unloading of a 40- or 50-ton car, will yield a very true sample. The difficulties increase greatly with the increase of the size of the particles, as in the case of lump or mine-run coal. If mechanical appliances for grinding are available, the larger amount should be taken, but a smaller sample well crushed down before quartering is better than a greater mass quartered down while the particles are still in larger pieces.

Assuming that the sample as taken is made up of the various kinds of material in proper proportion, the next important item is to maintain these variables in their ratios throughout the process of reducing the gross amount to a small working or laboratory sample. To insure this result, there must be maintained a certain ratio of size of the particles to size or weight of the mass. This, as a rule, is based on a formula which provides that the weight of the largest piece of impurity shall have a ratio to the weight of the mass of about 2: 10,000. For example, a mass weighing 10,000 grammes, or about 22 pounds, should contain no particles weighing more than 2 grammes. This would mean that the largest particle, as for example, a piece of iron pyrites, must not be over one quarter inch in its greatest diameter.

The final ratios of sizes, however, should be determined by the methods available for grinding. With mechanical appliances for obtaining the smaller sizes, a table of ratios with greater safety limits can be adopted than is perhaps practicable where the crushing is done by hand. If a power crusher is available, the entire sample should be passed through the mill and reduced to a size which will pass a ¼-inch screen. If the crushing must be done by hand, the first reduction in size of the particles should be such that the entire mass will pass through a 1-inch screen. When by quartering, the sample is reduced to 100 pounds, the size of the particles should be further reduced to a size that will pass a ½-inch screen, and with a 50-pound sample in hand the crushing should be carried to ¼-inch mesh. The subdivisions with their respective sizes are shown in tabular form as follows:

TABLE 1—*Size of Mesh for different subdivisions of sample.*

Weight of subdivision of sample (pounds).	Size of mesh to which each subdivision should be broken (inches).
500	1
250	¾
125	½
60	¼
30	⅛

Illinois coals are easily crushed in mills which are available at little expense. Hence it is entirely reasonable to require that gross samples when reduced in mass to 50 or 75 pounds, shall be passed through a mill set for grinding to approximately one eighth inch. For this work, a mill which is not of the jaw-crusher or roller type is preferred, since these types produce too large a percentage of fine material, and the harder pieces of slate, especially those of flaky or plate-like structure, are liable to pass in pieces having inadmissably large dimensions in two directions, even though the adjustment used would seem to be fine enough to prevent the passage of such material. A grinder of the coffee-mill type or one with projecting teeth on the grinding surfaces will be found to produce a more uniform size and the minimum amount of dust.

As a further precaution in maintaining a correct distribution of the various constituents, emphasis is placed upon the necessity of thorough mixing, followed by even selection of the remaining subdivisions. It is true that fine grinding contributes materially to this end but further care is necessary. It is entirely practicable to mix a 50-pound sample, ground as above described, by rolling in an oilcloth about five feet square. This is accomplished by taking one corner of the cloth and carrying it over the pile towards the diagonally opposite corner so as to cause the mass to roll over upon itself, then reversing the motion and repeating the process with the other two corners. Fifteen or twenty such alternations, depending somewhat upon the size of the sample, should be sufficient to effect an even mixture. Where available, however, especially in commercial sampling, a mixer is to be preferred. Such a device is most conveniently made in the form of a drum having cone-shaped ends capable of being closed air-tight, and mounted so as to revolve endwise.

The subdividing of the larger sample, to reduce it to a convenient size for transmission to the laboratory, requires special consideration as having an important bearing on the maintenance of the correct ratio of constituents. This may be best shown by the data given in Table 2.

Note in this table that series 1 and 2 are 3-pound samples taken by subdividing in the same manner the same gross sample of about 30 pounds. Each sample was ground to 8-inch mesh and sized. It will be seen that in series 1, duplicates *a* and *b* had 16.6 and 13.7 per cent of the 60-mesh size, whereas in series 2 the duplicates *a* and *b* had 22.5 and 23.1 per cent respectively. Note in Table 2 the great increase in ash in the fine size as compared with ash in the coarse material. For example, series 1 having an average of 14 per cent of ash in the coarse size has an average of 23.75 per cent in the fine portion. A similar increase in ash is seen in the corresponding sizes in series 2. The ultimate ash average for series 1 is 16.09 per cent and for series 2 it is 17.85 per cent. These values vary consistently with the variation in the percentages of fine material in the respective series. On the other hand, the duplicate halves *a* and *b* throughout, because of their uniformity resulting from the sizing process, show results in the several pairs which check very closely.

The values as presented in the table, therefore, show

TABLE 2—*Ash variations in different sizes obtained from duplicate 3-pound samples.*

Series	Mesh	Duplicate halves	Per cent of each size	CO_2 in "dry coal"	Ash corrected for CO_2 in "dry coal"	*a* and *b* composited by calculation
1_1	On 20	*a*	41.7	.40	14.11	
		b	48.4	.37	14.00	
1_2	Through 20 On 60	*a*	41.7	.85	15.55	
		b	37.9	1.00	15.42	*a*...16.32
1_3	Through 60	*a*	16.6	1.31	23.89	*b*...15.86
		b	13.7	1.38	23.65	Average..16.09
2_1	On 20	*a*	29.1	.53	15.91	
		b	25.0	.46	15.68	
2_2	Through 20 On 60	*a*	48.4	.94	16.23	
		b	51.9	.98	16.06	*a*...17.90
2_3	Through 60	*a*	22.5	1.32	24.09	*b*...17.80
		b	23.1	1.28	23.98	Average..17.85

clearly that in the process of subdividing the gross sample and in the further reduction of the sample as received at the laboratory, great care must be exercised to see that no part of the manipulation is of such a nature as will promote segregation of the constituents.

A riffle may be used to advantage after the sample has been reduced by quartering to about 30 pounds. At this stage the sample is ground to ½-inch size, hence the riffle openings may be ½-inch in width.

The second essential in taking and preparing a sample relates to the free moisture present, and requires that the changes in moisture content "must be under exact control so that at any stage the ratio of the moisture present to the original moisture of the mass may be definitely known."

In coals of this region especially, where the moisture in the coal as it comes from the mine averages from 10 to 15 per cent, the tendency toward moisture changes is very marked. For example, the process of crushing down the larger sizes affords an opportunity for the escape of moisture. Again, if the coal is spread out on the floor of a hot boiler room or left exposed to currents of air for any length of time there will be a serious change in the moisture factor. Another practice sometimes followed is that of assembling the various increments of the gross sample in a sack or other receptacle permitting a relatively free transmission of air. Samplers kept in this manner for any length of time or shipped in such containers will have a moisture content quite different from the original.

The methods employed, therefore, in collecting and reducing a gross sample must have special reference to this tendency on the part of the free moisture to escape. The work should be done rapidly in a room at or below the normal temperature and, so far as possible, with the use of closed apparatus which admits of the least possible exchange of the contained air. Precautionary measures of this sort should be made at the very outset. The gross sample, which is made up of small increments collected usually over a considerable length of time, should be inclosed in a tight box or clean garbage can having a tightly fitting cover which can be closed and locked against the possibility of change until the time for grinding and reducing.

FACE SAMPLING.

Since the procedure for obtaining the face samples described in this report serves as a good illustration of methods adapted to meet the principles above enumerated concerning the uniformity of composition and control of moisture, the details of the process for collecting, and subsequent preparation for shipment in the small container are here given in full. The methods thus described are applicable in principle to the collection of any and all samples from whatever source.

DIRECTIONS FOR COLLECTING FACE SAMPLES IN THE MINE.[1]

Selection of the face.—Choose three faces in the mine as widely separated as possible in order to give a good average of the coal for that mine. An attempt should always be made to get faces which have not been exposed more than 48 hours.

*Bulletin 29 of the Illinois State Geological Survey, by S. W. Parr.

[1] Substantially as given in Bureau of Mines Technical Paper No. 1 with the exception of the preparation, grinding, etc., of the sample.

Preparation of the face—(*a*). Fresh faces. 1. With a pick remove all loose coal (that which sounds hollow when tapped with the pick) and square up the face.

2. Brush off the loose coal, dust and powder stains from the face for a distance equal to the length of the blanket (5 to 7 feet).

(*b*). Exposed faces. For exposed faces the procedure is the same as above, except that before brushing the face, a strip of the coal one to two inches in thickness and about a foot wide is cut down the full vertical height of the face. This is done to give a comparatively fresh face for the sample.

Cutting down the sample.—1. Spread the blanket at the base of the clean portion of the face, taking care that it fits close at the bottom.

2. With a pick cut down a strip of coal 6 inches wide and 2 inches deep, the full vertical height of the seam. At least 6 pounds of coal should be cut down for each foot in thickness. All partings of sulphur, bone or slate over three eighth inches thick are rejected as these are supposed to be thrown out by the miner.

Preparation of the sample.—1. The blanket containing the sample as cut down should be spread upon a smooth hard place on the floor and the lumps all cracked down with a pick to a size suitable for readily passing into the grinder. This can be done directly upon the blanket.

2. Pass all of the sample through the grinder.

3. The sample is then riffled down until just enough remains to fill the sample can when the material is well shaken down and the can filled full so as to displace as much air as possible.

4. After filling as indicated under (3) the can is sealed with electrician's tape.

Where a portable mill is not available the crushing of the larger lumps must be accomplished by tamping. This is a slow and tedious process. With the mill, the grinding of the average gross sample can be accomplished in 30 minutes.

After reducing the sample to about 5 pounds, it is placed in a can and forwarded to the laboratory. The particular feature of the container is the skirted screw cap, which by use of electrician's tape wound about the base of the cover affords further security in sealing. On the inside it should contain a suitable ticket giving all the necessary data.

It should be a comparatively simple matter at any power plant to duplicate in principle the methods for sampling at the mine, and even to improve the conditions for preserving the moisture values.

SAMPLING THE CAR DURING UNLOADING.

A car of coal may be sampled to the best advantage in the process of unloading. An occasional half shovelful should be thrown into a proper receptacle so that by the time the car is unloaded approximately 200 pounds, evenly distributed throughout the load will have been taken. This will mean about one half shovelful for every ten full scoops. They are best taken in the process of shoveling from the bottom of the car, since the top coal rolls down and mixes fairly evenly with the bottom. It should be kept in mind that in taking a sample there must be obtained the different sizes of coal, fine and coarse in their proper proportions from the entire cross-section of the mass, and also an even distribution of the same lengthwise of the car. Even greater care must be taken to guard against loss of moisture in the process of collecting and in reducing the gross sample for the reason that as a rule the relative humidity outside of the mine is lower and the tendency of the moisture to leave the coal is correspondingly increased.

SAMPLING THE CAR WITHOUT UNLOADING.

It has been shown in Table 2, that the finer particles of a coal mass are higher in ash and hence have a greater specific gravity. They are therefore more likely to separate by gravity from the coarser material. On this account, if a car is to be sampled without unloading, it is necessary to dig well toward the bottom in order to obtain a representative sample. Three trenches should be dug crosswise of the load, one near each end and one near the middle of the car. These trenches should go down nearly to the bottom of the mass and each size be taken as nearly as possible in its proper proportion. Lump and run-of-mine lots are much more difficult to sample than screenings, but it should be noted that screenings may vary greatly, for not infrequently a car is partially loaded from one bin and finished from another which may be of a different size and composition. After obtaining the gross sample, the methods to be followed are the same as those already given.

COMPOSITE SAMPLES.

It is often desirable to composite a number of samples. In this way a single sample may be made to represent a much larger quantity of coal and thus cut down the time and expense involved in procuring the analytical data. In this procedure, however, it must be remembered that even greater care should be exercised in taking the several component samples. The amount of each sample entering into the composite must be in proportion to the mass which it represents, and finally a thorough and positive mixing of the composited mass must be effected before riffling down the same to the usual 5-pound quantity.

It is convenient to determine the amount of each sample to be taken by employing an aliquot system of weights. For illustration: Suppose we adopt 1 gramme to the 100 pounds as the unit which shall enter into the composite. Then a 100,000-pound car of coal should be represented by 1,000 grammes. In compositing, therefore, the entire content of each can will not be taken, but instead an aliquot proportion which will give to each car lot its due amount. It is preferable to use such a factor as shall utilize the major part of the several 5-pound samples. In this way the gross composite from ten cars would aggrgate 20 or 30 pounds in weight. It should be put into the mixer and revolved until a thoroughly homogeneous mass is obtained and then riffled down to a 5-pound sample as already described. For this procedure it is obvious that the necessary data should accompany the various samples. A ticket inserted in the can before sealing should give the data needed.

DUST OR DUFF DETERMINATION.

Specifications usually prescribe the maximum amount of dust allowed. This is designated as the material which will pass through a screen with ¼-inch openings. Obviously this item is not taken into account in mine samples, but should be determined in samples taken from commercial supplies. A determination of the percentage of dust is best made on one of the rejected quarters of the first subdivision. For example, a gross sample of 200 pounds is mixed and quartered. One of the quarters is taken and weighed. This is screened by shaking small portions at a time in a sieve with ¼-inch openings, preferably a sieve with circular perforations ¼ inch in diameter. The fine material is collected and weighed. These two weights together with the other necessary data as above noted should be entered on a ticket and inclosed in the shipping can.

The assembling of the data thus supplied by the several shipments should be made in tabular form at the laboratory.

How Daily Records Save Coal

THE weighing of coal as used has proved valuable in several ways. The management of a large plant closed a contract for coal supply with a certain dealer. The writer detected a very decided difference in the quality of the coal and a shortage of weights after the third car had been shipped on this contract. He reported the matter and made complaint to the management but the matter was not attended to as it should have been. Inside of a very short time the company had been billed with and paid for 70,000 pounds of coal which it had not received; in short, the weights given on the bills had apparently been raised 10,000 pounds per car, and further the coal had not been shipped from the mine specified in the contract.

The daily records showed this all up very plainly. Without these daily records these facts would not have been detected for months, if ever. How much would the company have lost on short weights alone in the course of a year, to say nothing of the losses resulting from an inferior grade of coal causing the rate of evaporation to drop from 6.5 to 4.5 pounds of water per pound of coal? Of course this contract was canceled and coal purchased elsewhere of much better quality and on a square deal basis.

The proper selection of coal for each plant is essential to secure the maximum economy. Some plants will find screenings to be the most economical, while a plant in the same block may find run of the mine to be the best. Still another plant might find nut, pea and screenings the best. Local conditions must be considered, and tests are the only way in which the best kind of coal can be determined. What your neighbor finds to be the best may be the worst for your plant. Price per ton has very little to do with this matter; it is purely a case of the cost of fuel per pound of steam.

On testing several plants the writer found that run of mine gave higher evaporative efficiency than screenings, but the higher efficiency was not proportional to the higher cost per ton of run of mine, hence the screenings proved to be the more economical. This is not necessarily always the case however. Coal prices unfortunately are not as a rule based upon the relative values as steam producers. Before deciding on any particular class of coal, or upon any particular mine for supply, tests should be made on several classes of coal from several mines, and that class and mine selected which shows the most economical results.

It certainly is profitable to keep these daily records; the cost is not great, and the possible savings enormous when compared to the cost of keeping the records. Most factories maintain a cost keeping department at an expense of several hundred dollars per month. The object is, of course, to ascertain the cost of producing each and every part manufactured and to prevent unnecessary costs in manufacturing; but at the best this department can hardly be expected to save an amount equal to its cost of maintenance, as it has as a rule no authority over the production departments and can only call attention to an increase in costs. This expense of maintaining a cost keeping department is nevertheless apparently justifiable even in smaller plants; but the maintenance of a department to keep costs on power, heating, lighting, water supply, fire protection, etc., under the supervision of a capable engineer, is seldom attempted, though the resulting savings almost invariably will result in an amount far in excess of the cost of maintaining such a department.—*S. J. H. White in the Iron Age.*

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